THURSDAY, DECEMBER 30, 1915.

SCIENTIFIC RESEARCH AND CHEMICAL INDUSTRY.

THE future prospects of the British dye industry, and the organisation of it and other scientific industries, have been the subjects of much attention lately. The developments taking place in Japan, Russia, Italy, and America in regard to the manufacture of synthetic dyes were discussed by Dr. F. M. Perkin in a lecture recently delivered before the Society of Dyers and Colourists at Bradford. The latest American enterprises in this industry were described in NATURE of December 16, p. 429, and the conclusion was drawn that, in a few years, America will be very largely self-contained in the matter of dye wares. This condition may, with reasonable certainty, be postulated of the other industrialised countries, including France, and, one may hope, the British Empire. If this anticipation be realised, it will mean that the synthetic dye industry, with all the allied trades in fine chemicals, will have entered on a new phase of their development. Before the war these industries were very largely a German monopoly. After the war they will be comparable with the brewing and distilling trades in that the wants of each industrialised nation will be supplied almost entirely by manufacturers of the same nationality. Only a few dyes or fine chemicals having specially desirable properties will find their way across the frontiers, just as is now the case with alcoholic beverages of international reputation.

So far as the existing dyes and fine chemicals are concerned, there can be little doubt that in the course of twelve months or so processes will have been worked out for the manufacture of these products on an industrial scale. At first it will certainly not be found possible to produce these materials so cheaply as was formerly done by our German rivals. Both the capitalists and the consumers will need at first to exercise considerable patience and forbearance. Later, as technical experience increases, the cost of production will certainly diminish. But even if all the synthetic products on the market before the war are captured in this way and manufactured at a reasonable price, this development, although representing a considerable advance, will not suffice to ensure the continued stability of the chemical industries. There are no ideal dyes, drugs, or other fine chemicals; all are capable of improvement, and, in spite of the distractions of the war, many German chemists are engaged in the amelioration of existing chemical products. Only quite recently the report has filtered through of a further considerable advance in the production of synthetic indiarubber. These developments call for corresponding efforts on our part, and the demand arises for more and better-trained chemists.

The view has been put forward in certain quarters that now is the day of the chemical engineer. It is undoubtedly true that a chemist with some mechanical aptitude will find a useful outlet for this bent in the chemical factory, but unless he exercises the trained chemical mind, and the synthetic ability to make chemical discoveries, he will never have the problems on which to utilise his engineering talents. Perkin's mauve, Meldola's blue, Knorr's antipyrine, Ehrlich's salvarsan, Baekeland's baekelite, and many other valuable discoveries were made by chemists working at these problems from a purely chemical point of view, and although some of these eminent investigators may have had more or less mechanical aptitude enabling them to put their discoveries into operation on a more extended scale than in the laboratory, yet the indisputable fact remains that they made these discoveries first and foremost because they were trained chemists with the chemical insight into the molecular constitution of the materials they studied. As a conneting link between chemist and engineer, the chemical engineer may serve a useful purpose, but he can never become an efficient substitute for the chemist. The latter alone with his own hands, and usually with cheap improvised apparatus, makes the synthetical discoveries which then become the factory problems for the engineer.

As regards the organisation of chemical workers for industrial research, it must not be assumed that conditions applicable to Germany will be readily adopted in the United Kingdom. Due regard must be made for the highly developed individualism of the British character, with its sporting instincts, its love of personal liberty, and its disinclination to sink natural predilections and to take the point of view of the State. It is useless to deplore these apparent shortcomings of the national temperament; indeed, in certain contingencies they are to be regarded rather as virtues. This preference to fight for one's own hand has probably, in many a recent desperate battle, kept intact the thin extended khaki line against overwhelming hordes of more amenable

individuals who have acquired the pack habit. Yet while we cannot but admire the instinct for individual action thus displayed, it must be confessed that success in modern conflicts—military or industrial—is mostly commanded by disciplined forces organised for co-operative effort against the common enemy.

At a meeting of the London Section of the Society of Chemical Industry held during November, a long discussion took place on Dr. M. O. Forster's suggestion that a chemical intelligence department should be instituted by the Government as a branch of the Board of Trade. Although the majority of speakers agreed that an organisation for chemical industry was necessary, there appeared to be a disinclination to entrust the Government with control of this department. A scheme for a co-operative organisation established by the chemical industry itself had already been advocated in September by the *Chemical Trade Journal*. This development, although a consummation devoutly to be wished, scarcely seems practicable in view of the separatist tendencies which still manifest themselves from time to time, both in the chemical profession and among chemical industrialists.

After the war much of the plant newly erected for the manufacture of high explosives will be available for the production of synthetic dyes and other fine chemicals. The relationship between these factories and the existing chemical works will need to be dealt with sympathetically and impartially by a competent authority, otherwise much loss of capital and energy will ensue as the result of competition between organisations working on similar lines. The elimination of this internal friction in our chemical industries would be a useful function of the suggested chemical intelligence department.

Many reasons have been advanced to explain our inability to develop the industries based on chemical synthesis. Taken separately, these factors are inadequate to account for the failure. Collectively they are effects of a fundamental cause discovered in early-Victorian times by Justus von Liebig, who, after a visit to these islands, declared roundly that "England ist nicht das Land des Wissenschaftes." One may well ask what chance have we of reforming in this respect? A gleam of hope arises from the following consideration. Formerly the advantages of a German university training were confined to 1851 Exhibitioners and to a few of the more well-to-do among us. To-day considerably more than a million of our fellow countrymen, drawn at an impressionable age from every station in life, are pursuing their scientific studies at an open-air German university under conditions which compel their undivided attention. Many of them realise very forcibly that the advantages possessed by their enemy instructors are due entirely to scientific organisation. When our soldier-students return to civil life will they insist upon scientific control of all national affairs? In that possibility lies our strong hope.

THE MOLECULAR VOLUMES OF LIQUIDS.

The Molecular Volumes of Liquid Chemical Compounds from the point of view of Kopp. By G. Le Bas. Pp. xii+275. (London: Longmans, Green and Co., 1915.) Price 7*s*. 6*d*. net.

TO anyone interested in the progress and development of science in this country, and in the attitude of the general community towards it, it is a significant and welcome sign that English publishers should now be found willing to undertake the issue of highly specialised works of the kind under review. For nothing would seem more clearly to indicate the spirit which is gradually coming over the community than the fact that there should be a demand, even if limited, for such a book. No doubt this demand has been stimulated by the influence of the more active and progressive teachers in our universities and leading schools of science. This series of monographs on biochemistry, physics, and inorganic and physical chemistry, comprising up to now some three dozen volumes, each the work of an eminent specialist, marks a new departure in the scientific literature of this country. The books are not text-books in the ordinary sense; that is, they are not intended to be used in or to accompany class-teaching. They are addressed mainly to those who have already passed through lecture-room courses, and who before embarking upon the work of investigation in some particular branch of experimental inquiry are desirous of making themselves acquainted with the present state of knowledge in that special department. Their publication at the present time is most opportune.

The titles of some of the volumes may not, at first sight, suggest that they have any practical bearing upon the problems with which we are more immediately confronted. But to disparage them on this account is to take a very restricted view of their utility. As they deal, for the most part, with what may be called frontier—or pioneering—work, they are of the very greatest use to those who are bent upon exploratory

service. They may be compared to the maps which aid in the initial stages of an exploration; like all maps of a partially surveyed district, they may be imperfect and at times even erroneous; they indicate not only trodden paths, but suggest new routes; they serve to confirm imperfectly established facts, and lead to the correction of errors. It is almost a platitude to say that nearly every new departure in science seems at the time it is made to have no very obvious relation to the needs or conditions of our daily life. No one can possibly set a limit to the prospective usefulness of even the most recondite physical fact.

In the book before us, which has occupied nearly eight years in its preparation, Mr. Le Bas has brought together the results of the large amount of experimental work which has been spent upon the subject of the molecular volumes of liquid compounds since the time of Kopp, now upwards of seventy years ago. Kopp was not the first to attack this subject, but he was certainly the first to attempt to give a definite significance to the conception by seeking to establish the conditions under which proper quantitative values might be ascertained. Up to his time no rational method had been suggested whereby these values could be determined under presumably comparable conditions—say, at their normal melting- or boiling-points. Objections, of course, may be urged against the employment of either the melting point or the boiling point as a valid condition of comparison, but in Kopp's time no other course was open to him, and there can be no question that it did serve to bring out regularities and relationships which otherwise would have been wholly obscured. Kopp's example in this respect has been followed by almost every subsequent worker in this special field. It is with the large mass of material which has thus been accumulated that Mr. Le Bas's book mainly deals, and it is for the reason that the work is fundamentally based upon the principles laid down by Kopp that the particular form of its title is due.

Of course, Kopp and his immediate followers suffered under the disability that present-day conceptions of chemical constitution were wholly unknown to them, and possibly even wholly undreamt of. These ideas are mainly due to a development of the chemistry of carbon compounds long subsequent to Kopp's day. Although Kopp made determinations of unimpeachable experimental accuracy on a number of organic compounds, his interpretation of the results they afforded was limited, and, indeed, occasionally erroneous, owing to his lack of knowledge of the effect of constitutive influences. He compared things between which we now know no real analogy exists, and made generalised deductions from wholly irrelevant and inconsistent data. The work of his successors was more or less guided by the light of contemporary theory, but, of course, even in their case it only reflects the state of knowledge or speculation at the particular period it was undertaken.

Now the great merit of Mr. Le Bas's monograph is that it not only collects and groups in a systematic arrangement the results of all the work hitherto published on the molecular volumes of liquid chemical compounds, but it discusses and seeks to interpret these results with the aid of all that is known or surmised concerning the constitution of such compounds, however it may have been ascertained. In this manner Mr. Le Bas has been able to give a great expansion and at the same time a greater precision to the conception of the intimate relation which indubitably exists between such a physical property as molecular volume and chemical constitution. Thus he shows, for example, that no physical property is apparently so well adapted to elucidate the ring structure of a compound as its molecular volume, and he expresses the hope that this will henceforward take its legitimate place among other physical properties as an instrument of research. That the determination of this value is readily possible, and with a degree of accuracy amply sufficient for its purpose as an indicative factor, had already been shown by the author. He finds that the values at the boiling point may be calculated with approximate accuracy by the following simple formula :—

$$\frac{d_0}{d_t} = 1 + c\left(1 - \frac{273}{\text{B.P}}\right)$$

the only data necessary being the density at 0° and the boiling point. The mean value of the constant c, as deduced from a considerable number of inorganic liquids investigated by the present writer, is 0·463. An almost identical value of c is obtained for organic cyclic compounds without side-chains. By means of the above formula the molecular volumes of liquid compounds may be calculated with an error of less than 1 per cent. In open-chain compounds the value of c increases by 0·024 for every addition of CH_2.

The book concludes with a suggestive summary of the theory of molecular volumes, in which the author discusses the present position of the additive principle, its value, and its limitations. He clearly shows, what, as he observes, had already been pointed out by the present writer, that there is a periodic relation in the atomic values of the various elements, and he illustrates this by a diagram, with special reference to the non-metallic elements. He summarises the discussion in the

main body of the work concerning the variations in the volumes of the atoms, more particularly in the cases of oxygen, sulphur, nitrogen, and chlorine. He traces the effect of constitutive influences, *e.g.*, the influence of the homologous increment, unsaturation, and ring structure; valency, and groups; and lastly he discusses the special conception embodied in molecular volume and its relation to other physical properties, such as boiling point, surface tension, and viscosity.

The book is by no means easy reading, but it bears on every page the evidence of thoughtful, critical insight, and may be unreservedly commended as a faithful and accurate digest of the state of present knowledge upon what is confessedly a complicated and intricate subject.

T. E. THORPE.

THE PARTITIONS OF NUMBERS.

Combinatory Analysis. By Major Percy A. MacMahon. Vol. i., pp. 300. (Cambridge: At the University Press.) Price 15*s.* net.

THOSE who, like the present writer, have been privileged to hear Major MacMahon give an account of his methods of solving the problems of which the well-known Latin Square is typical—problems of interest to many who are not professed mathematicians—have been waiting for this treatise with eagerness. Volume i. has now appeared, and it amply fulfils the expectations which have been formed. If we may quote from the preface, the object of the work is to present to mathematicians an account of theorems in combinatory analysis which are of a perfectly general character, and to show their connection as parts of a general doctrine. The modesty of the author forbids him to mention that the greater part of the work is his own, as well as most of the important theorems which are treated. It is fair to say that Major MacMahon has developed a new line of mathematical work, and that many of the main theorems, rescued here for the first time from the author's papers in scientific periodicals, must form an essential part of text-books on higher algebra in the future.

The author enters a justifiable protest against the relegation of combinatory analysis to a part of the theory of numbers, for the theory is algebraical up to the point of determining the enumerating generating functions. He traces his method back to Laplace, who used these functions for the theory of probability, but he has greatly simplified Laplace's method by the extended use of symmetric functions.

The work is divided into six sections, each subdivided into a series of chapters. As a detail of arrangement, it would surely have been more convenient for a reader to find the chapters numbered consecutively throughout, instead of beginning again with each section. Section i. contains the theory of symmetric functions, and of distributions into parcels and groups in general, and it is especially notable in its clear account of the uses of Hammond's operators. The theory of separations is taken up in section ii., where an important generalisation of Girard's well-known formula is obtained. Permutations are taken up in section iii., where is proved what the author has ventured to call the "master theorem." This theorem really deserves such a title in a subject of this nature, and this section is, in fact, one of the most interesting in the book. The applications of the theorem to such problems as the sum of the nth powers of binomial coefficients are very elegant, and the chapter on lattice permutations is a very valuable piece of work. The theory of the compositions of numbers appears in section iv., and further applications of the master theorem are developed in this connection. Simon Newcomb's celebrated problem suggested by a game of "patience" is treated in a very attractive manner. Section v. takes up the question of distributions on a chess board, preceded by a discussion of the perfect partitions of numbers. This section will completely displace any other account of such problems, and shows the power of the analytical method very strongly. The sixth and last section is concerned with the enumeration of the partitions of multipartite numbers.

These brief references will serve to indicate the main outlines of the work, but they necessarily miss many of its characteristic features. The book is interesting even when the analysis becomes somewhat cumbrous, which the author allows it to do as little as possible. It is published by the Cambridge University Press, and maintains the tradition of excellence of this series. While congratulating the author, we hope that the second volume will not be long delayed.

THE TINTOMETER.

Light and Colour Theories and their Relation to Light and Colour Standardisation. By J. W. Lovibond. Pp. xii+90. (London: E. and F. N. Spon, Ltd., 1915.) Price 6*s.* net.

MR. J. LOVIBOND is known as the inventor of the tintometer. He has written no preface to the present book in the ordinary acceptation of the word, but commences with a chapter on "Purpose," which is largely devoted to enumerating the awards he has received from international juries and various scientific socie-

ties, and a list of industries which have adopted the tintometer. Mr. Lovibond tells us also that colour is "a determinable property of matter, and the purpose is to make known methods of colour analysis and synthesis which have proved of great practical value in establishing standards of purity in some industries." "The purpose is also to show that the methods (tintometer?) are thoroughly scientific in theory and practice," and also that "a new law (the law of specific colour development) has been developed." This is a new name for well-known observational results.

The first chapter has some introductory remarks, and there is a page and a quarter (with a coloured plate) devoted to what is headed "past" (colour) "theories." This does not give any novel matter, nor does it contain any criticism of the six theories which he enumerates. Chapter ii. is the most interesting of all, as it relates to the "evolution" of the tintometer. The tintometer is an admirable instrument for registering the colours of objects, opaque or transparent, which do not show pure colours. Its principle is to match such colour illuminated by white light by sending a beam of the same white light through one or more red, yellow, blue, and neutral-tinted glasses on to a white screen having various depths of colour till the colour of the object is matched. The choice of the glasses, and the skill with which Mr. Lovibond ground them to give the varying depths of colour which he required, approaches to the marvellous. His method of regaining his standard tints if lost is ingenious, so that observations made with the same quality of white light will always give the same results. The one weak point is the choice of the white daylight used, which is light from a north sky, that, of course, can vary in quality from day to day. A recognised standard of artificial light would be better.

Mr. Lovibond rather fights shy of the spectrum, and has given no results of matches to the band of spectrum colours by the absorption method. The spectrum throughout its length is unmatchable by this method.

When he makes statements regarding the spectrum analysis he sometimes gets out of his depth. He tells us that there is one red ray in the spectrum between A and B which cannot be absorbed, and that this (red) energy has never been investigated "as a separate form of spectrum red." Mr. Lovibond should look to the absorption by his glasses.

The book has its value when the theory part is left out, and may serve as a practical guide to "tintometry" through the useful examples which are shown in its later chapters.

OUR BOOKSHELF.

Field Analysis of Minerals for the Prospector, Mining Engineer, Traveller, and Student. By G. D. McGrigor. Pp. 86. (London: *The Mining Magazine*, 1915.) Price 3*s.* 6*d.* net.

THE methods of mineral determination here advocated by the author have been found useful by him as a prospector beyond the reach of laboratories. He has no doubt observed that a student who has passed through an ordinary course of chemistry is still poorly equipped for dealing with natural chemical compounds as they are presented to him in the field. In some colleges, however, the chemical curriculum includes a course in practical mineralogy, in which field conditions are, so far as possible, reproduced. Even Mr. McGrigor's book will not do away with the desirability of a sound course of inorganic chemistry as a prelude to such work as he marks out, and few will agree that this foundation should involve only "a very short period of instruction." The student of chemistry, for instance, will know that when Mr. McGrigor speaks of substances containing sulphur on p. 13, he means sulphides, and that there are also such things as sulphates; he will note the slip on p. 12, where the weight in air divided by the weight in water is said to give the specific gravity of a substance; and he will know (p. 19) that the oxidising flame does not "impart" oxygen to the material under examination. Possibly he will never have used microcosmic salt, and this is just where the author might have helped him (p. 22), by pointing out cases where it provides conclusive tests, instead of suggesting that it gives the same results as borax. Sir Warington Smyth is cited as the authority for some of these statements; but the author's practice must have led him somewhat farther.

The reactions described in the systematic portion usefully include those of tellurium, vanadium, osmium, and tantalum, which are omitted in many treatises. A just balance of simple wet tests and ordinary blowpipe-tests is indicated. The use of some good text-book on mineralogy is very properly recommended, especially Brush and Penfield's "Manual of Determinative Mineralogy," to which Mr. McGrigor's book may well serve as a pocket introduction.

G. A. J. C.

Egypt of the Egyptians. By W. Lawrence Balls. Pp. xvi + 266. (London: Sir Isaac Pitman and Sons, Ltd., 1915.) Price 6*s.* net.

MR. LAWRENCE BALLS not only knows Egypt of the modern Egyptians, but during his years of residence there he bore his part in adding to her material prosperity. Indeed, he writes with authority on the problems of cotton cultivation, and while applying himself to their solution he formed opinions upon many other subjects connected with the country. This book is the result of such study and observation on the spot, and it is well worthy of study in its turn.

The chapters on the Nile, on irrigation, and the crops are perhaps its most valuable sections,

but the author is evidently a keen and thoughtful observer, and he has much to tell us on the reconstruction of the country. We fully agree with him that the real Egyptian of Egypt is not to be found in the towns but in the country villages, and we have been particularly interested in reading how he succeeded in training *fellahîn*, or members of the peasant class, to undertake the skilled work of observation required in an experimental garden, including the use of a chemical balance and other laboratory appliances. These later parts of the book are preceded by three chapters on the ancient history of the country. Here the author has no special knowledge, but he has in the main followed sound authorities, and the outline he gives serves as an effective foil to the account of modern developments.

Among the numerous half-tone plates, reproduced from photographs, several make effective illustrations and others are of technical interest. But a few are not of a distinctive character, either in subject or treatment, and, like the not very artistic representation of the Egyptian flag on the cover, scarcely do the author justice. Perhaps we are hypercritical. But first-hand information and experience of Egypt or the East are so rarely coupled in their record with a real sense of style; when we do meet them we are, perhaps, inclined to be ungratefully impatient of accessories which tend to disguise the combination.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

An Application of the Rules of Zoological Nomenclature.

MR. GERRIT S. MILLER, Jun., has published (Smithsonian Misc. Coll., vol. lxv., No. 12, November 24, 1915) the results of his investigation of a set of casts of the famous Piltdown fossils as compared with a large series of actual anthropoid and human skulls. Modern casts are made with great accuracy, and Mr. Miller is a competent and experienced authority on the skulls and teeth of mammals. He confirms the doubt already stated by many investigators as to whether or no the Piltdown lower jaw belongs to the same individual as the Piltdown skull, and goes further in the discrimination of the anthropoid character which has been obvious to all the investigators. He admits that the skull is human, but decides that the lower jaw is that of an extinct chimpanzee.

Mr. Miller's arguments are impressive, and may turn out to be convincing when they have been examined by persons who have seen the actual specimens. But Mr. Miller, who is also experienced in the application of the rules of nomenclature, has thought it necessary to name and describe a new species of chimpanzee, founding it on a jaw that he has never seen. Thus, if his opinion be sustained, the very famous Piltdown jaw, discovered by Mr. Dawson, made known to science by Mr. Dawson and Dr. A. Smith Woodward, and lodged in the British Museum, will have to be cited as the type of *Pan vetus*, Gerrit S. Miller.

P. CHALMERS MITCHELL.

Zoological Society of London, Regent's Park, London, N.W., December, 1915.

THE SCIENTIFIC ORGANISATION OF INDUSTRIES.

AN article by M. Jules Garçon on the scientific organisation of industries appears in the *Bulletin d'Encouragement pour l'Industrie nationale* for September–October, p. 383. After describing the proceedings of the deputations to Messrs. Pease and Runciman on behalf of the Royal and Chemical Societies, with representatives from the Society of Chemical Industry, the Society of Public Analysts, and the Institute of Chemistry, as the sequel to memorials presented to the Prime Minister on March 1, which have already been treated of in NATURE (May 13, p. 295), and giving a useful analysis of the various points raised, the sympathetic replies of the Ministers are alluded to. An account follows of the proceedings at the annual meeting of the Society of Chemical Industry at Manchester in July of this year, with reports of the addresses given by the president, Dr. M. O. Forster, Mr. Charles Carpenter, Prof. H. E. Armstrong, and Dr. Beilby. Next follows a summary of the address delivered by Sir W. Ramsay to the British Science Guild at its annual meeting on July 1, and, lastly, the details of the Committee and Advisory Council on Scientific and Industrial Research, appointed under the Board of Education.

M. Garçon sums up these various opinions and resolutions in several pages of "conclusions," which it may be useful here to indicate. The English men of science are unanimous in their view that the technical and scientific knowledge of the nation should be utilised to the greatest possible extent during the war, as well as to guarantee future progress. They demand the formation of a permanent central committee; that scientific investigation shall be encouraged; that the teaching of science in the universities shall be reformed; and that the scientific societies lend their aid to effect these changes. They demand *prompt* and *decided action*. The committee in connection with the Board of Education has now been appointed; it consists of men of acknowledged ability in science and industry, and is now busying itself with various items on the programme drawn up in accordance with the demands of the scientific societies. It has, besides, a very considerable annual grant to dispose of. It is the closer association of science and industry which is most to be desired, and an effort must be made to arrange university courses so that they will furnish young technologists able to experiment and to assist manufacturers. Centralisation is also imperative, for much has been lost in England for lack of concentrated effort.

M. Garçon notes that while the Société d'Encouragement, under the chairmanship of M. Léon Lindet, has done excellent work in succeeding in its attempt to induce chemical manufacturers in France to collaborate, and while in France there has been formed a "Union des Sociétés industrielles de France," also while in

the United States various engineering societies have collaborated as the "United Engineering Society," little is being done in this direction in Great Britain. The Society of Chemical Industry is attempting to collect a register of manufacturing chemists, but it is an expensive undertaking. It is, however, hoped that something tangible may be published in 1916.

There are obviously two questions, which, however, are closely related. First, how can the scientific and technical ability of the *entente* be utilised to the best effect in prosecuting the war? and, secondly, how can the efforts which Germany will undoubtedly make after the war to secure complete industrial ascendancy best be defeated? M. Painlevé, the French Minister for Education, points out the necessity for the best brains and the best plant in France being utilised to assist the Army and Navy. This war is more and more becoming dependent on engineers and chemists, and to conquer, all talent must be mobilised on a national footing. The excellence of the idea is obvious; the difficulties arise in arranging details. In England, too, it may be said that every man connected with science and industry is eager to do his utmost to help his country, but it is by no means easy to assign to each his task. Progress is, however, being made, although perhaps not so fast as might be desired.

The production of munitions of war goes on apace. Not merely are old and long-established works being driven to their utmost capacity, but large new works are being erected for the manufacture of chemicals required for war purposes. These are being well equipped with modern plant, and will turn out enormous quantities of such materials. But it is to be noted that the apparatus with which they are furnished differs but little from that required in many chemical works; tanks, steam coils, towers, stills, filter-presses, and the like are necessary, and are being provided. Now this raises a serious question. The war will not last for ever, and it would appear to be necessary to make arrangements for the utilisation of such plant and equipment, of labour and superintendence, when there is no longer a demand for thousands of tons of high explosives. The problem is a pressing one, and must not be long postponed. We cannot afford to "wait and see." It would be disastrous if, after the war, all staffs were dismissed, all plant scrapped and sold, and the whole organisation broken up.

The Committee under the Board of Education is a body charged with the furtherance of "industrial research." The object is admirable; but it appears to the writer that it is much more pressing to consider how to utilise these new and extended works in the future than to attempt to develop new and untried industrial processes, unless, indeed, these can be carried on in the munition works after the end of the war. The task is one of great magnitude. First and foremost, it involves coming into touch with every chemical manufacturer in the country and appealing to his patriotism to do his best, in conjunction with his fellows, to co-operate for the benefit of all. Is this possible? For there exists a feeling of mutual distrust, difficult, if not impossible, to eradicate; and this feeling is not unnatural. Even in well-known processes, improvements are constantly being made which may have the effect of rendering remunerative what would otherwise not pay. Often the "tips" are not patentable; often to patent them would be to give them away to competitors. Little wonder that the successful manufacturer has resolved on a policy of rigorously excluding the public from his works and patenting as few processes as possible. Our patent laws lend themselves to litigation, and litigation means loss of time and annoyance, if not loss of money. For this reason, too, the chemical manufacturer is not willing to co-operate with his fellows. He will tell what he sells; he will not tell what he makes. Yet it might perhaps be possible to induce at least a certain number of manufacturers to draw together for patriotic reasons.

In the uncertainty whether Protection will become the policy of this country, or whether the stocks accumulating in Germany will not be "dumped" in Great Britain at the close of the war, no one feels inclined to risk capital. Propositions for a customs union among the Allies have been hinted at, but are not as yet seriously discussed. Yet without such safeguards, or perhaps an even more drastic policy, German commercial aggression cannot be withstood. It will again be national organisation against lack of organisation. And even though the Hohenzollerns and the Habsburgs may be dethroned, it is too much to expect that the German nation will lose her power of acting as a whole, and bringing all her commercial and manufacturing combinations to bear on the commerce and manufacture of the Allies, with the view of annihilating them. For a time, patriotic societies may refuse to buy German goods; but such goods will be insidiously introduced through neutral countries under faked names, and before long the commercial war will be actively prosecuted. That is what we must look forward to, and it surely demands the most careful planning if we and our friends the Allies are successfully to combat such industrial warfare. The prospect is not pleasing; it is very difficult to face; and if we are to place ourselves in a position to do so, serious political changes are imperative in this country. The practical men *must* obtain control; they *must* be assisted by the highest scientific advice procurable. Moreover, all must co-operate for their country's good and for their own salvation.

It would appear to be the legitimate task of the Committee on Industrial Research to endeavour to make a beginning. If their powers are insufficient, let them be increased. They might add to their number men of affairs and industrial experience likely to be helpful. The most useful form which "research" can take at the present moment is the inquiry how our industries are to meet German attack after the war is over.

WILLIAM RAMSAY.

MOTHERCRAFT AND INFANT WELFARE.

NATIONAL existence is to a large extent dependent upon the quantitative value of the population, and diminution of population is the downward path which, if continued, must eventually lead to national extinction. The population of any country is the resultant of the balance between births and deaths and between emigration and immigration. In the British Isles, while emigration is a material factor in reducing population, the principal influence securing its continuous increase is the excess of births over deaths.

Unfortunately for the nation, a persistent and serious fall in the birth-rate in the United Kingdom has been in progress for many years, from 30·7 per 1000 of population in 1887 to 24·0 in 1913, and to 23·3 in the June quarter of this year. What this means is better seen from the actual number of births; in England and Wales alone for the last September quarter the births were 28,000 fewer than in the corresponding quarter of 1913! Fortunately, the natural increase of population during the same period has almost been maintained by a striking diminution in the death-rate. It is of interest that decline in the birth-rate is by no means confined to the United Kingdom, but has occurred in many countries on the Continent, the principal factor causing it here and elsewhere being a diminution in the size of the family, chiefly, apparently, in consequence of intentional restriction of child-bearing.[1]

We cannot anticipate any increase in the birth-rate at present, but rather a further decrease, for the toll exacted by the present war on the flower of the nation's manhood, the fathers and prospective fathers of her children, is sadly heavy.

It is of the utmost importance, therefore, that every means should be employed which may tend to maintain the effective fertility of the nation to the utmost practicable extent. If it be impracticable to increase the number of births, it is practicable to reduce still further the number of deaths of infants and children. As a matter of fact, infant mortality[2] has undergone a striking decline since the beginning of the century—from about 158 in 1900 to 105 in 1914. But, even so, the possibilities of saving child-life are by no means exhausted. If the chief causes of mortality during infancy and the first five years of life be examined, it will be found that one-fifth of the deaths in infancy and nearly one-third of the deaths in childhood are due to measles, diarrhœa and enteritis, whooping-cough, and tuberculosis. Bronchitis and pneumonia account for about one-fifth of the remaining deaths, and conditions operating at and before birth (premature birth, injury at birth, etc.) for another fifth. Measles and whooping-cough in themselves are not mortal diseases, the deaths arising mainly from exposure, inefficient nursing, and unhygienic conditions, and much may be done to reduce the mortality from these and the other diseases mentioned by improved care of the sick. It is evil conditions of environment, and not poverty only, which kill children and damage survivors; this is well shown by the variation of the death-rate among children in different parts of the community. In 1911–13 the infant mortality in Wigan was 165, in Nelson 87, and the death-rate at ages one to five in the same localities was 119 and 58 respectively. The children of miners, a relatively prosperous portion of the community, die at the rate of 166, of doctors at the rate of 40!

Unfortunately, during the last year the infant and child death-rates have shown an alarming tendency to rise, and during the first half of the present year the mortality from measles has doubled. It can hardly be doubted that this is largely due to the increased employment of women and consequent neglect of the home, and to the diversion of the activity of health visitors, district nurses, and others, who hitherto have done splendid work in helping to look after the children of the poor, into other channels more closely connected with the war.

With the view of reducing the mortality from measles, the Local Government Board has just issued an order making measles and German measles notifiable throughout England and Wales, and enabling local authorities to undertake measures for the care of patients suffering from these diseases.

A national campaign to promote the welfare of mothers and infants has also been inaugurated, and meetings were held at the Guildhall on October 25 and 26.

Municipal enterprises in the form of ante-natal clinics and maternity homes, infants' departments and milk depôts, feeding of expectant and nursing mothers, pre-school and post-school clinics, etc., should be encouraged in every way; what may be done in this direction is well shown by the example of Bradford, which has established departments in all these branches.[3]

Another factor which both lowers the birth-rate and tends to increase infant mortality is maternal mortality in connection with child-bearing, for obviously the mothers who thus lose their lives, had they lived, would in many instances have borne other children, while the infant is more likely to survive when cared for by its mother. In the four years 1911–14 the number of deaths of mothers assigned to complications of pregnancy and childbirth in England and Wales was 14,045, corresponding to a rate of 4·0 per 1000 births. The mortality among mothers due to child-bearing varies in different parts of the country. It is highest in Wales and Westmorland, and may there, perhaps, be ascribable to deficiency of skilled assistance in childbirth; it is also very high in textile areas, where female labour is largely employed. But the question is a complicated one, for we find that the mortality

[1] See "Report on Maternal Mortality in connection with Child-bearing and its Relation to Infant Mortality" (Rep. of the Med. Officer of the Loc. Gov. Board) for many of the data and details mentioned in this article.
[2] "Infant mortality" is the number of deaths of infants during the first year of life per 1000 births.

[3] See "Maternity and Child Welfare." By E. J. Smith. (P. S. King and Co.) Price 1s. net.

from child-bearing is practically the same in St. Helens and in Croydon—two towns which differ markedly in general social and sanitary circumstances, and West Ham, a relatively poor and squalid neighbourhood, has a rate lower than that of towns like Brighton, Bournemouth, and Hastings! When it is realised that the mortality from child-bearing varies from 8·54 in Dewsbury to 2·20 in West Ham, it follows that by the adoption of improved measures of care of the prospective mothers before and at childbirth, we may hope materially to reduce what is one of the most pathetic forms of loss of life. The care of prospective mothers is still more necessary at the present time, when there is such a considerable increase in female labour, and such care will, in addition, diminish the number of still-births and of damaged children born.

Not only the maintenance, but the further increase, of our present rate of increase of population must be regarded as one of the most serious and urgent of national problems and responsibilities at the present time. The child is now a national asset of great price, and for the successful rearing of the greatest possible number we must look to improved care of prospective and actual mothers, and improvement of mothercraft and of infant and child welfare. R. T. HEWLETT.

MEDICAL RESEARCH.

THE first annual report (1914–1915) of the Medical Research Committee has been published. It bears date October 18, which is very appropriate, because that is St. Luke's day, the day of the beloved physician. St. Luke's medical knowledge, doubtless, was that which Browning ascribes to Karshish: we have improved on St. Luke, so far as medicine is concerned. This report is a notable bit of work. The Medical Research Committee, as we all know, was born of the Insurance Act, and was endowed, at birth, with a penny in the pound. It was intended to study the diseases of civil and industrial life. It was born in August, 1913. A twelvemonth later came the war. *Pendent opera interrupta*—the work on the diseases of dangerous trades, the work on the commoner maladies of our big cities, was more or less declared off. The nation was thrown, all of a sudden, all unprepared, into that most dangerous of all dangerous trades, War.

In this crisis, this day of judgment—for that is the meaning, and the only meaning, of the Greek word crisis—the Medical Research Committee took a very wise course. It added to its first scheme of work a series of proposals for special work, to be undertaken by the committee, in direct connection with the war and for the assistance of the Army Medical Department; and it made up its mind that as the war goes on there will be less and less work to be done for the nation apart from the Navy and the Army.

Not only was the plan of work upset by the war, but the Central Research Institute, the buildings of the Mount Vernon Hospital at Hampstead, had to be transformed into the Hampstead Military Hospital. And, as the proposals for amalgamation with the Lister Institute, after very careful consideration, have been suspended, we might say that the Medical Research Committee is still without a proper home of its own. But it has found many temporary homes or resting-places for its work, and a welcome for it everywhere.

The researches into subjects connected with the war cover a very wide range. Work has been done at many of the general hospitals of the Territorial Force, and at other military hospitals. Valuable help has been given towards the preparation of the medical history of the war. Wound infections, typhoid and paratyphoid infections, and cerebro-spinal fever have been very carefully studied; so have many problems apart from bacteriology. Special interest attaches to Dr. Leonard Hill's study of asphyxiating gases, and to Dr. John Freeman's expedition to Galicia, whence he brought back cultures of strains of cholera-bacilli, for St. Mary's Hospital to make anti-cholera vaccines for the Serbian Government and for our Mediterranean forces; and to Dr. Leiper's discovery that a fresh-water snail is the intermediate host, between man and man, of the Bilharzia parasite. Other important studies include the work done on "neurological" cases, and the testing of British makes of salvarsan.

In brief, this report is a very fine record of good work done under most unexpected conditions. The moral is, that he or she who works for the forces of the Allies is working also, in the long run, for the nation at home. It is not a weakness, but an added strength, of science, that it can adapt itself to circumstances, and venture into new fields of research at a moment's notice. When the war is over, there will be time enough for the workers under the Medical Research Committee to come back to win other laurels for science in the ways of peace.

FOOD ECONOMY.

A NUMBER of useful pamphlets are being issued just now on how to economise in war time in the matter of food. One of these, by Prof. W. H. Thompson, of Trinity College, Dublin, we noticed a short time ago. The latest that has come into our hands, entitled "Food Economy in War Time" (Cambridge: At the University Press, price 6*d*.), should be widely read and acted upon. It is written by Profs. T. B. Wood and F. G. Hopkins, both of whom can speak with authority, one from the agricultural, the other from the physiological, point of view. It is written in a clear style, such as the man in the street, or, what is more important, the woman in the kitchen, can understand.

There are many in this country who cannot economise; they already exist on the minimum. Saving must therefore be accomplished by the comparatively well-to-do, and that this can be done without detriment to health is clearly shown.

It may mean some self-sacrifice, but self-sacrifice just now is the duty of all. There must not be recourse to expensive foods, the quantity of animal food must be reduced and replaced by vegetables, especially those rich in nutriment. Above all, there must be no waste, no throwing away, for example, of bones and dripping.

The little pamphlet is full of useful hints, based on accurate scientific knowledge and trustworthy statistics. The nation roughly spends 600,000,000*l.* per annum on its food. The authors estimate that it is not possible to save more than a tenth of this if due regard is to be paid to health and to the necessity of feeding children well at any cost. Sixty million pounds saved a year looks a large sum, but in these days, when millions are treated almost like sovereigns used to be, it will not be a very large fraction of the total necessary saving if the war is to be carried out to a successful end. Statisticians tell us that the ordinary savings of the nation in peace time amount to 400,000,000*l.* This will have to be increased to 1,600,000,000*l.*; and sixty millions is only one-twentieth of the additional 1,200,000,000*l.* which must go in the shape of taxes and loans to war purposes. The other nineteen-twentieths of this colossal sum must come from savings in other directions, or else the saving in food must be greater; we can only hope that Profs. Wood and Hopkins have placed their estimate too low.

SIR JOHN RHYS.

THE wonderful romance of the life of Sir John Rhys and the great work which he did for Celtic learning have formed the theme of many a writer during the past week. In the pages of NATURE it is appropriate to speak of the man as he appeared to his scientific friends. The dominant qualities of his mind, as they were again and again revealed in intimate personal contact, were a never-failing freshness and elasticity together with the keen insight which seized at once upon the larger problems. "Well, what has been going on in science lately?" was his invariable question when we met after an interval; and his deep interest was always there, whether the subject was radio-activity, or some new light upon heredity and evolution, or Arrhenius's hypothesis of life-bearing germs, persisting from the eternal past, permeating all space, and driven by the pressure of light to all the worlds. And it was just the same in the province where he was master. John Rhys was always looking for the big, far-reaching conclusions. Place-names in the Iberian peninsula were the data for inferring a former southward extension of the Basques; while their northern migration was tentatively suggested by the names of chiefs among the Picts, that mysterious people of which scarcely anything is certainly known. The present writer has heard him tell of the Irish chieftain of whom it is recorded in time-worn stone that he was "the summoner of the fairies"—evidence for a fascinating interpretation of an ancient folk-lore. The fairies, being an older race, living in caves and clinging to the hills, would still be called on by their conquerors, to assist, for example, in repelling some new invader. Such were the delightful subjects of which he talked with scientific friends, and those who would wish to trace, in brief compass, the working of his master mind, cannot do better than read and re-read his presidential address to Section H of the British Association at Bradford (1900), in which he "endeavoured to substitute for the rabble of divinities and demons, of fairies and phantoms that disport themselves at large in Celtic legend, a possible succession of peoples, to each of which should be ascribed its own proper attributes."

With regard to his methods, one little incident may be recorded. About five years ago Lady Rhys told the present writer of a recent journey in Spain, and how the Principal, although with no conversational experience of the language, went up to a man, and, without any hesitation, began to ply him with questions, reading them out of a Spanish conversation book. In this way, taking opportunities as they occurred, he made remarkably rapid progress.

As head of a college it was always his anxiety to promote friendliness and sympathy, and he must, I think, have been satisfied that his efforts were attended with success. The kindness of his heart was well known to those of his many friends who were in trouble, and they at least could dimly imagine the blank left by the death, in 1911, of the comrade who had trodden with him the noble journey of his life.

It is hoped that these few sentences will enable the reader to realise in part the important place held by this great man in the brotherhood of learning, and will reveal something of the affection and admiration felt for him by his friends, and especially by the society to which he brought such high distinction. E. B. P.

NOTES.

THE action of the Government in assigning a sum of about 30,000*l.* for the development of scientific and industrial research seems likely to have an important influence in British possessions overseas. The Commonwealth of Australia is apparently prepared to expend whatever sum is necessary to establish and administer an institution for such research, even if the cost amounts to half a million. The *Morning Post* of December 24 makes this announcement, but no details are given; and it is not clear whether the Premier of the Commonwealth expressed the intention of his Government to put aside the amount named for an institution of scientific research in relation to industry, or only gave a general assurance that such an outlay would be forthcoming when believed to be necessary. We shall look with close attention for the announcement that the substantial sum mentioned in the report has actually been granted for the establishment of a national laboratory in Australia.

THE funeral of Sir John Rhys, principal of Jesus College and professor of Celtic in the University of Oxford, was attended by a large and representative gathering of Welshmen, members of the University, and others. We learn from the *Times* that among the representatives of learned institutions and other public bodies present were Dr. Bradley (the British Academy), Principal Griffiths (the University of Wales and University College, Cardiff), Mr. D. Lleufer Thomas (Junior Deputy Chancellor, University of Wales), Sir Vincent Evans, chairman, and Mr. Edward Owen, secretary (Royal Commission on Ancient Welsh Monuments), Mr. W. Edwards and Mr. J. M. Edwards (Central Welsh Educational Board), Principal Roberts (University College, Aberystwyth), Prof. Morris Jones (University College, Bangor), and Prof. E. Tyrrel Green (St. David's College, Lampeter). The University of Oxford was represented by the Vice-Chancellor (the Dean of Christ Church), Sir Herbert Warren, many heads of houses, professors, and other members.

A MEMORIAL service for the late Sir Henry Roscoe was held on December 22 at the Rosslyn Hill Unitarian Chapel, at which the Royal Society was represented by the president—Sir J. J. Thomson—Prof. Arthur Schuster, Sir Edward Thorpe, and Prof. Smithells; University College (University of London) by the Vice-Chancellor, Sir Alfred P. Gould, Sir Thomas Barlow, Prof. M. J. M. Hill (chairman of the Academic Council), and Dr. Gregory Foster (the Provost); the Victoria University of Manchester by the Vice-Chancellor, Sir Henry Miers, and Prof. H. B. Dixon; the Chemical Society by Dr. Smiles and Prof. J. C. Philip (secretaries), and Lieut.-Col. A. W. Crossley (foreign secretary); the Society of Chemical Industry by Sir Boverton Redwood and Mr. Watson Smith, a former demonstrator in the Owens College, and late editor of the Journal of the Society of Chemical Industry; the National Physical Laboratory by Dr. Glazebrook and Dr. Harker; the Lister Institute by Dr. Harden; the Royal Commissioners for the Exhibition of 1851, Mr. Evelyn Shaw. Among others present were:—Lord and Lady Courtney, Lord Ashton of Hyde, Viscount Iveagh, the Master of Peterhouse, Sir A. W. Ward and Miss Ward, Sir Joseph Larmor, Dr. Emerson Reynolds, Sir William Tilden, Prof. Millar Thomson, Mr. Frank Scudder (late scientific assistant to Sir Henry Roscoe), Dr. Horace T. Brown and Miss Brown, Dr. Beilby, Dr. C. A. Keane, Dr. H. G. Colman, Dr. F. G. Ogilvie (director of the Science Museum, South Kensington), Mr. Gilbert Redgrave (secretary, Royal Commission on Technical Instruction), Dr. Aubrey Strahan (director of the Geological Survey of Great Britain), and Mr. J. S. Parkin, of the Castner-Kellner Alkali Co. The interment took place on December 23 at the Brookwood Cemetery, in presence of the immediate relatives, a few intimate friends, and representatives of scientific bodies. Among those who attended were Sir Edward Thorpe, Prof. Schuster, Prof. Perkin, Prof. Smithells, Dr. Harden, Dr. Keane, Dr. Colman, Mr. Chas. Cresswell, Mr. Reid, and Mr. Evelyn Shaw.

THE Local Government Board has issued an Order entitled "The Public Health (Measles and German Measles) Regulations, 1915," applying throughout England and Wales a system of notification of these two diseases, and enabling local authorities to undertake measures for the care of patients suffering from them. The Order, which comes into force on January 1, 1916, provides for notification of cases of measles and German measles to the medical officer of health of the district by medical practitioners, or by parents or guardians, or any other person in charge of the patient; these maladies are thus brought into line with several other diseases which have long been notifiable. Notification has been introduced mainly with a view to the control of the spread of infectious diseases, but has hitherto not been generally applied to measles, because the disease is infectious at an early stage, and before it can be definitely recognised. The powers provided by the present Order may tend to limit the spread of the disease, but they will probably be found much more useful in reducing mortality from it. On an average about 11,000 deaths from measles occur in a year in England and Wales, and these are confined chiefly to children under five years of age. Measles itself is not a fatal malady, death being due to complications—principally bronchitis, pneumonia, diarrhœa, and convulsions—which are largely brought about by undue exposure and inefficient nursing during the illness. As a result of notification the medical officer of health can adopt measures to reduce the proportion of fatal cases by rendering advice and providing nursing assistance to the poorest families.

WE regret to announce the death, in his ninety-second year, of Dr. H. Debus, F.R.S., formerly professor of chemistry at the Royal Naval College, Greenwich, and lecturer on chemistry at Guy's Hospital.

THE death is announced of Mr. W. Rupert Jones, who was for forty years assistant librarian of the Geological Society of London, and for a long period prepared the society's valuable annual record of geological literature. He was born in 1855, the eldest son of the late Prof. T. Rupert Jones, and retired in 1913.

SIR H. EVELYN OAKELEY, whose death is announced at eighty-two years of age, was the author of a treatise on algebra and geometry, a collection of mathematical problems, and many reports on educational subjects. At Cambridge he graduated as tenth Wrangler in the Mathematical Tripos of 1859, and was elected to a fellowship at Jesus College in the Midsummer term, 1860. From that date he continued in residence as fellow and mathematical lecturer until he vacated his fellowship by marriage in September, 1862. He was appointed H.M. Inspector of Schools in 1864, and Chief Inspector of Training Colleges in 1885.

THE *Glasgow Herald* of December 21 reports that a strong earthquake was felt on December 19, at 8.5 a.m., at Arrochar and Tarbet, the former being at the head of Loch Long and the latter at the head of Loch Lomond. The shock, which was of intensity 5 (Rossi-Forel scale) at Arrochar, is regarded as the strongest of those felt during the present century in

this district. The first, which occurred on September 18, 1904, also attained an intensity of degree 5. The disturbed area contained 564 square miles, its centre being nine miles west of Dunoon. A slighter shock (intensity 4) occurred on July 3, 1908. It was felt over an area of about 400 square miles, with its centre eleven miles north of Dunoon. The epicentre was thus displaced about fourteen miles in a north-easterly direction. From the evidence at present available, a similar further displacement appears to have occurred in the epicentre of the recent shock.

THE accounts of the local committee of the Manchester meeting of the British Association, held in September, lately issued, show that the resolution to observe the strictest economy in view of the exceptional circumstances in which the meeting was held was faithfully kept, and the local officers are to be heartily congratulated on the success of their efforts in this as in other directions. The expenditure amounted to only 862*l.* 15*s.*, and 22 per cent. was all that it was necessary to ask from the guarantors. On the occasion of the previous meeting, in 1887, the expenses reached 3652*l.*, and 35 per cent. of the much larger guarantee fund was called up. The meeting was in every way a success; it was attended by many eminent scientific men, the papers and discussions were of high value, and the arrangements gave such satisfaction that at the concluding meeting of the general committee many influential members expressed the hope that future meetings might be "run" on the same lines, excluding much of the lavish and costly expenditure on entertainments and excursions which has often proved a heavy charge on the local funds.

IN the House of Commons on December 20, Sir Philip Magnus asked the Minister of Munitions whether his attention has been directed to a recent resolution of the British Science Guild urging upon his Majesty's Government the necessity of immediate steps being taken to establish a national school of technical optics, with a view of affording opportunities for the scientific training in this country of artisans and other students in the theory and practice of the several operations needed for the manufacture of the optical instruments and appliances which have hitherto been largely imported from Germany, and are now being imported into this country from the United States of America and elsewhere; and, if so, whether he proposes to take any action in the matter. The question was answered by Dr. Addison as follows:—I understand that the resolution in question was passed by the British Science Guild in July, 1914. The object in view appears to be undoubtedly of the greatest importance, and my right hon. friend has had before him for some months the necessity for increasing the number of skilled workmen available for the manufacture of optical instruments for war purposes. I am advised that a considerable number are being trained at various works engaged on Government contracts. As regards the permanent supply of such workmen, I understand that the matter is receiving the careful attention of the Board of Education. Sir Philip also asked the Minister of Munitions whether he is aware that a small but efficient school of technical optics has been for some time in existence in connection with the Northampton Polytechnic Institute, Clerkenwell; that the governors of that school have purchased at a cost of 13,000*l.* a site for its extension, but have no funds available from which they can complete the necessary extension and equipment, and that unless funds are forthcoming they will be compelled to sell the site to avoid further payment of interest; and whether, in these circumstances, and having regard to the need of a well-equipped school, the Minister of Munitions can see his way to make a grant of money towards the further extension of the school. The answer given by Dr. Addison was:—I am sorry to hear of the difficulties with which the governors of the institute are faced, but the matter does not directly concern the Ministry of Munitions, and I regret that I cannot hold out any prospect of a grant from funds at the disposal of the Ministry. I understand, however, that the matter is under the consideration of the Board of Education and the London County Council.

AT the sixth annual general meeting of the Society of Engineers (Incorporated), held on December 13, the awards of premiums made in respect of papers published in the Journal of the society during 1915 were announced as follows:—The president's gold medal to Mr. A. H. Barker, for his paper entitled "Some Future Developments in Heating and Ventilation"; the Bessemer premium, value 5*l.* 5*s.*, to Mr. Alphonse Steiger, for his paper on "The Modern Development of Water Power"; a society's premium, value 3*l.* 3*s.*, to Mr. S. G. Turner, for his paper entitled "Law and Engineering; Some Points of Contact"; a society's premium; value 2*l.* 2*s.*, to Mr. F. Grove, for his paper on "Main Roads, Past and Present." The following were elected as members of the council and officers for 1916:—*President*, P. Griffith; *Vice-Presidents*, H. C. Adams, W. B. Esson, and W. Noble Twelvetrees; *Members of Council*, H. Adams, C. T. Walrond, F. L. Ball, B. Geen, the Rt. Hon. Lord Headley, F. H. Hummel, T. J. Gueritte, B. H. M. Hewett, G. A. Becks, and G. O. Case; *Associate Member of Council*, C. E. May; *Hon. Secretary and Hon. Treasurer*, D. B. Butler.

STUDENTS of eugenics will be greatly interested by Dr. C. B. Davenport's recent paper on the inheritance of violent temper (*Journ. Nervous and Mental Disease*, xlii., 1915, pp. 593–628). His results are taken from the study of 165 family histories of wayward girls in State institutions. From the facts, clearly set forth in the text and the pedigrees of eleven families in graphic form, the conclusion is drawn that "the tendency to outbursts of temper . . . whether associated with epilepsy, hysteria, or mania or not, is inherited as a dominant trait, typically does not skip a generation, and tends ordinarily to reappear, on the average, in half of the children of an affected parent." Hence it follows that "unaffected members of a fraternity who select an emotionally-controlled consort will only exceptionally, if ever, have affected offspring." This is comforting from the eugenic point of view, and some measures for isolating the worst of the "affected" might at least be discussed.

THE Irish Fisheries Office has lately published two interesting reports (Fisheries, Ireland, Sci. Invest., 1914, iii., iv. [1915]). The first of these, by Miss J. Stephens, deals with sponges from various localities around the Irish coasts, the Triaxonida (*Hexactinellida auct.*), the Tetractonellida, and the Astromonaxonellida. Forty-four species are enumerated, of which six are new to science, and twenty-six are recorded from the Irish marine area for the first time. Of special interest are a Biscayan and Azorean species of Hyalonema, *H. infundibulum* and *Leucopsacus scoliodocus*, hitherto known only from the Japanese Sea and Cape Verde. The other paper describes the results of a biological survey of Blacksod Bay, Co. Mayo, as compiled by Lieut. G. P. Farran, from identifications furnished by many workers at special groups. There are valuable faunistic and ecological observations, among which the influence of the neighbouring whaling station on the littoral fauna and flora is noteworthy. The equipment of the Blacksod station is so good that the detrimental effect of its refuse is confined to an area extending for at most 200 yards on either side of the quay.

THE Carnegie Institution of Washington has lately issued part i. of the third volume of Howard, Dyar, and Knab's great work on the mosquitoes of North and Central America and the West Indies. This comprises the first instalment of the systematic description of genera and species. The illustrative plates form vol. ii. of the work, which has presumably not yet been published, as we are unable to trace its receipt. According to the system adopted by the authors, all "mosquitoes" fall into a single subfamily—the Culicinæ—which, with the Corethrinæ and the Dixinæ, form the family Culicidæ. The Culicinæ are divided into two tribes: the Sabethini, comprising eight genera, and the Culicini, a very large and comprehensive group, subdivided into Deinoceritines, Culicines, Megarhinines, and Anophelines; the two last-named are not included in the part now before us. The work of Dyar and Knab on the structure of mosquito larvæ and its importance in classification is naturally prominent in this volume, and British entomologists will notice that many of the genera established by Theobald on characters drawn from the scaling are set aside. The systematic student will be greatly helped by the diagnostic tables provided, and he will find in all cases a very full synonymy. The introductory historical sketch of the classification of mosquitoes and the frequent accounts of the habits of the insects and their larvæ will ensure a welcome to the book from naturalists who are not specialists among these insects, especially in view of their great importance with regard to tropical diseases.

"VARIABILITY and Amphimixis" is the title of a recent paper by Prof. L. B. Walton (*Amer. Nat.*, xlix., 1915, pp. 649–87), in which he describes the result of observations on the varying sizes of zygospores in Spirogyra formed from "lateral" conjugation (fusion of two adjacent cells of the same filament), as compared with those formed from "scalariform" conjugation (fusion of two cells in distinct filaments). The zygospores resulting from the former process are relatively 26 per cent. more variable in length, and 31 per cent. more variable in diameter, than those resulting from the latter. Prof. Walton regards the scalariform conjugation as an example of sexual reproduction, and the lateral as a "quasi-parthenogenesis"; hence he argues, in opposition to Weismann, Jennings, and others, that "amphimixis . . . decreases and does not augment variability (cumulability), although amphimutability may temporarily be increased." The unfamiliar terms in this quotation are from the author's classification of variations, in which "amphimutations" are defined as "arising through the transference of factors by the combination of two ancestral lines in accordance with Mendelian principles, but exhibiting *per se* no definite progress"; while "cumulations" arise "through causes at present unknown, but which, from the progressive results obtained, may be assumed to originate in accordance with definite laws." On the other hand, Prof. Walton names four subdivisions of "abnormations" "apparently not originating in accordance with definite laws." The classification might be more valuable if the author would tell us exactly what he means by the phrase, "in accordance with definite laws."

THE value of the wood of *Cotoneaster frigida* for making the heads of golf clubs forms the subject of a letter from Sir Herbert Maxwell printed in *Kew Bulletin*, No. 9, p. 414. The wood has been tested for the purpose and found suitable, and may in time replace persimmon, which has succeeded crab and beech. *Cotoneaster frigida* grows easily in this country and seeds freely, but it takes some forty years to produce timber of suitable size. It is also probable that the wood of *Cotoneaster bacillaris* may be found suitable for making club heads; it also grows freely in this country.

IN *Kew Bulletin*, No. 9, Mr. J. H. Lace describes a number of new species from Burma, chiefly from the neighbourhood of Maymyo, and mostly of his own collecting. A large number of new species, including several new trees, have been discovered in this region in recent years owing to the activity of forest officers, and our knowledge of the flora of this region is far from complete. A new tree, *Allospondias laxiflora* (Anacardiaceæ), is among the more interesting of the plants described, as this tree, which is a conspicuous one on the dry limestone hills which rise suddenly out of the plains on both banks of the lower Salween, has been imperfectly known since 1862, when it was described by Kurz as a Buchanania. The original specimen was collected by Brandis, and apparently consisted of flowers only, and it is not known to what plant the leaves described by Kurz may have belonged.

COTTONSEED meal, the ground cake left after the oil is pressed from the seed of cotton, is now used extensively as a cattle food; but whilst it may be fed profitably to horses, cattle, and sheep in moderate amounts, poisoning, and often death, may occur as a result, especially if the animal has not been gradually accustomed to it. It is generally avoided in the case of pigs on account of the numerous deaths associated with its use. The toxic properties of the meal are attributed by Messrs. W. A. Withers and F. E.

Carruth (*Journ. Agric. Research*, vol. v., p. 261) to the substance *gossypol*, which was first isolated by Marchlewski in 1899, from the cottonseed, and patented as a prospective dyestuff. This substance is now shown to have a strong toxic effect upon all the animals experimented with. It occurs in the so-called "gland-dots," or "resin-glands," of the seed, and also in the cambium layer of the bark of the root. The problem that now awaits solution is to devise a means of rendering this substance non-toxic. Whilst gossypol can be readily oxidised to a non-toxic form, and can also be rendered harmless by iron salts, the seed tissue surrounding the cells prevents the free action of reagents, so that difficulty is presented in practice in rendering the cake innocuous by a simple treatment. This, no doubt, will be devised before long.

LAST April the American Philosophical Society held an interesting "symposium," resembling the joint discussions of the British Association, on the condition of the earth's interior. The three addresses given are now published in the recently issued bulletin of the society (vol. liv., 1915, pp. 279–308). Prof. T. C. Chamberlin studies the subject from a geological point of view, Prof. H. Fielding Reid describes the results and bearing of seismological investigations, and Dr. J. F. Hayford considers the earth from the geophysical point of view. The writers agree that the conclusions towards which we are tending are not yet firmly established. The methods of research were devised too recently to admit of dogmatism. But it is contended that the varied evidence afforded by geological, seismic, and tidal studies converges in favour, not only of a solid, but of an elastico-rigid, earth, in which liquid and viscous lacunæ, if any such really exist, must be confined to very moderate dimensions. Dr. Hayford's address is specially valuable owing to the many suggestions which he offers for further investigation.

AN important series of earthquakes began on June 22 in the Imperial Valley in the extreme south-east corner of California. They are described by Mr. Carl H. Beal in a valuable paper in the Bulletin of the Seismological Society of America (vol v., 1915, pp. 130–149). A slight fore-shock at about 7.40 p.m. on the day mentioned was followed by two severe earthquakes of intensity 9 (Rossi-Forel scale) at about 8 and 9 p.m. These earthquakes originated in nearly the same region, the buildings damaged by the first shock being completely destroyed by the second. Six persons were killed by falling walls, and the relatively small loss of life is attributed to the brief duration of the shocks and the warning given by the earlier of the strong shocks. Mr. Beal, who traversed the district by motor-car and collected information by means of the telephone, has drawn approximately a series of seven isoseismal lines of intensities 9 to 3. The first is an elongated ellipse about 10 miles in length; the last is circular in form, and includes about 50,000 square miles. The district is traversed by at least three major faults, trending in a south-easterly direction. The fault with which the earthquakes were connected is the San Jacinto fault. This is apparently a branch of the San Andreas rift, the great movement along which gave rise to the Californian earthquake of 1906. In the Imperial Valley, the course of the fault is hidden by recent deposits, which also obscure any permanent deformation that may have taken place at the surface. There is, however, some evidence for thinking that the San Jacinto fault traverses the epicentral district along the axes of the isoseismal lines.

THE Royal Geographical Society in its lectures and its journal keeps abreast of the times. From time to time instructive articles dealing with the areas of the war appear in the *Geographical Journal*. An exhaustive paper by Mr. Douglas Freshfield, on the southern frontier of Austria, appears in the December number (vol. xlvii., part 6). Mr. Freshfield discusses in detail the fighting which has taken place, and concludes that the Italian operations have intentionally been limited to defence in order to secure positions essential for repelling possible attacks on Lombardy or Venetia from the Trentine highlands. A number of maps show the present and proposed frontiers in relation to relief and nationality, and show clearly the justification of the Italian claims in the southern half of the Trentino and north of Trieste. The paper concludes with some account of the little-known frontier lands of Herzegovina and Montenegro.

IN his "Social Anatomy of an Agricultural Community" Mr. C. I. Galpin (Agricultural Experiment Station of the University of Wisconsin Research Bulletin 34, May, 1915) has made attempts in a new and important line of research in social geography. It is a study of the relation of farmer and townsman in the Walworth County of Wisconsin. This survey results in the delimitation of a number of agricultural communities, each with its village or city centre. The area of this nature, linked with the urban centre, may be designated as the country of that town or by the term greater prefixed to the town name, thus emphasising the close relationships of the two. Local government will be last, the author expects, to recognise these communities, and administrative areas give false boundaries. The interrelationships between the town and its country area disclose a mesh of correlated social interests uniting the city dweller and the farmer. The rural problem thus becomes part of what Mr. Galpin designates the "rurban" problem. Neither rural or urban problem can be adequately discussed apart from one another. Various aspects of the problem are indicated, and the paper is full of suggestive ideas.

THE Monthly Meteorological Charts of the Indian Ocean issued by the Meteorological Office contain in each issue an ice-chart of the southern hemisphere for the ensuing three months, based on the records of the last eleven or twelve years. The ice-chart of the January, 1916, issue is fuller than usual, and gives the distribution of pack in the Antarctic Ocean in January, February, and March, in addition to the location of recorded bergs in past years. A long list is also given of the icebergs in the Southern Ocean for these three months from 1885 to 1915. The innovation on the chart is welcome, but it might be more thorough. Neither in the Ross nor Weddell Seas are the data complete. Off Wilkes Land there are no indications

of pack, and in the South Atlantic the ice-observations by Dr. Bruce in the *Scotia* are not incorporated. These latter might conceivably be of direct importance to merchant vessels; the others could affect only exploring ships. It is remarkable that while the extreme limits of ice approximate to the parallel of 40° S. in the Atlantic and Indian Oceans, records of icebergs are very few in the forties and fifties in longitudes east of Greenwich. In the Pacific, where the ice limits are further south, icebergs are numerous, as they also are in the waters immediately to the east of Cape Horn. The dimensions of some of the bergs recorded by merchant ships suggest probable exaggerations, but it would be impossible satisfactorily to edit these data, and so they must stand as given.

La Nature for December 4 has an interesting popular article on the methods of testing guns and ammunition, being the second article of a series on "Les Laboratoires de la Guerre." The first subject dealt with is the determination of the muzzle velocity of projectiles, measured by the well-known Boulengé chronograph; then follows a description of the crusher gauge and its use for measuring pressures in the gun. The apparatus in use in France for gauging the bore of the guns for possible distortion on firing and measuring the horizontal and vertical displacement after firing are described and illustrated. The stability on firing is a most important question, and is registered by means of suitable points attached to the gun and wheel axles which score directly on plates suitably placed in relation to the movement to be traced. With the latest Schneider guns it is stated that a glass of wine placed on the rim of the wheel is not upset on firing the gun. The velocity of recoil and return is measured by means of the tuning-fork method, the vibrations of the fork and travel of the gun being recorded on a blackened bar fixed to the top of the gun. The temperature attained on firing successive rounds is estimated by the use of a series of fusible crayons of chosen melting point to form a scale of temperatures permitting measurement to 20° C. An interesting feature of the article is the description of the drastic tests to which field pieces are subjected. At the Creusot factory four of the carriages are run by electric power over a circular track of *pavé*; at the Schneider works the carriage is drawn by an engine running alongside the test track over every conceivable object likely to be met with in the field, various road surfaces, ditches, railway lines, etc., and they are also tested under horse traction. In dealing with projectiles the degree of fragmentation is considered, and some illustrations given of the effect of shell fire on a field battery and on a concrete wall.

THE Research Laboratory of the Eastman Kodak Company at Rochester, New York, was organised in 1912, and in full working order early in 1913. Since then Dr. C. E. K. Mees and the staff working with him have published the results of their work in various journals in this country and in America, and as it is likely that many who are interested have not these journals available, the company has just issued a seventy-six page pamphlet, which contains abstracts of all the scientific papers published by them during the years 1913 and 1914. This step cannot fail to be appreciated by those who are privileged to receive a copy. There are three chief departments of the laboratory, namely, chemistry, physics, and photography. The pamphlet contains abstracts of twenty-two papers—none chemical. Perhaps the chemical work done is too intimately connected with the factory to justify its publication. The abstracts give the chief results obtained, and hence are useful without reference to the originals. The greater number of the abstracts are intimately connected with photography, and deal with such matters as sensitometry, colour processes, brightness of image, resolving power, etc., and some are of more general interest. L. A. Jones has investigated the utility of the standard acetylene lamp designed by Mees and Sheppard, which consists of an acetylene flame from a single jet and a diaphragm in front that isolates about 5 mm. of it. It is simple, requires but little attention, and is otherwise satisfactory. The "Colour of Illuminants," by L. A. Jones, "The Axial Chromatic Aberration of the Human Eye," by P. G. Nutting, "The Visibility of Radiation," by P. G. Nutting, are other papers which will appeal to many who may care but little about photography.

THE second series of Science Reports of the Tôhoku Imperial University, vol. iv., No. 4, contains a fifth communication "On the Chief Constituent of Japan Lac," by Rikô Majima. This is a remarkable compound, of a type that has not hitherto been found in nature, namely, an aromatic compound, with a very long aliphatic side-chain. The compound itself, which is described as urushiol, is unsaturated; but it can be reduced to a saturated compound, hydrourushiol, to which a definite formula can now be assigned, namely, $1:2:3\text{-}C_6H_3(OH)_2(C_{15}H_{31})$. The aromatic nucleus is of the familiar pyrocatechol type; but it contains a normal pentadecyl group attached as a long "straight-chain" to the nucleus in the position immediately adjacent to the two hydroxyl groups. The position of the double-bonds in the side-chain of the unsaturated urushiol is still undetermined.

AN account of the construction of some laboratory electric furnaces, given in an article in NATURE of December 16, contained a sectional diagram and a description of a single-tube furnace. The purpose of the article was mainly to explain the principles followed in the design of such furnaces; and Messrs. Gallenkamp and Co., Ltd., wish it to be understood that the diagram, which was drawn by the contributor of the article, should not be taken as an actual representation of the details of their patented furnaces. The specification of their laboratory furnaces of various types, with particulars as to performance, advantages, and prices, will be found in a special pamphlet (List No. 65) recently issued by Messrs. Gallenkamp, who will send a copy to science teachers and other workers engaged in instruction or research upon application being made to them at 19/21 Sun Street, Finsbury Square, London, E.C.

A CATALOGUE of books on Africa, just issued by Mr. Francis Edwards, High Street, Marylebone, deserves attention. In its classified lists are many books from the library of Mr. Charles Cowen, editor of the *Cape*

Monitor, and a large number of volumes dealing with the South African war of 1899–1902. The catalogue also includes more than sixty oil paintings by James Baines, who had a wide experience of southern tropical Africa, and was with Livingstone on his Zambezi expedition. The only other known collections of Baines's pictures are in the possession of the Royal Geographical Society and the museum at Kew Gardens. The catalogue is exclusive of Mediterranean Africa and the Red Sea border.

OUR ASTRONOMICAL COLUMN.

SUN-SPOTS AND PRESSURE.—A paper dealing with pressure data has been received from Dr. Gilbert S. Walker, who is engaged on a comprehensive statistical investigation in world meteorology with the object of laying the foundation of a secure system of seasonal weather forecasting. The data are treated as in the case of rainfall and temperature in preceding papers. For pressure the Indian area is characterised by negative correlation coefficients, whilst in the western hemisphere and boreal regions the opposite sign prevails. A general tendency is observable for the pressure coefficients to be opposite in sign to those for rainfall, indicating that their variations are dominated by a common cause, and temperature would seem to have little influence on either. Humidity, especially in the upper air, appears to control the relationship between sun-spots and temperature (Mem. Indian Met. Dept., vol. xxi., part xii., No. vi.).

HARMONIC ANALYSIS OF THE MOTIONS OF THE HELIUM STARS.—The dynamics of our stellar system are engaging an increasing degree of attention, and although Alcyone, and, recently, Canopus have been the suggested super-suns, it is still a question of establishing the existence of the general orbital movement. Prof. von S. Oppenheim adopts the working hypothesis that such movement exists, and some results of his work in this field were recently noted in this column (October 21). In an earlier investigation Prof. Oppenheim employed harmonic analysis to answer cognate questions. This is now recalled because these investigations have lately been carried a stage further (*Astronomische Nachrichten*, 4822). Pursuing the analogy drawn from the swarm of minor planets, he observes that a precise parallelism probably exists if instead of dealing with the totality of the stars the movements of the galaxy-grouping helium stars (type B) are alone taken into account. Employing the methods of the earlier papers to deal with the Lick results for the radial velocities of 233 stars of this type, taking proper motions from the Boss Catalogue, and making an approximation in regard to parallax, he finally obtains as developments of expressions involving respectively proper motions and radial velocities two Fourier series the terms of which are in good agreement regarding an orbital position angle of the sun, a result considered to establish the reality of the original hypothesis (*i.e.* that the stars, including the sun, move in circular orbits about one ideal centre). The numerical results which may be specially mentioned concern the position of this centre. Taking $\Omega = 234° 40'$ as the ascending node of the plane of the sun's way, with inclination $i = 53°$, then the sun viewed from the centre of the system appears in R.A. 203° 55′, declination −34° 0′. The corresponding apex of the solar motion is R.A. 266°, and declination +34° 37′.

THE ASTRONOMICAL AND ASTROPHYSICAL SOCIETY OF AMERICA.—We have received a copy of the second volume of the publications of this peripatetic society. The meetings reported range from the eleventh, 1910 —attended by a number of important English astronomers—to the fifteenth, 1913. Abstracts are given of the papers. A most important feature of the volume is an appendix devoted to Halley's comet. The special committee of the Astronomical Society made suggestions that led to Mr. Ferdinand Ellerman taking an expedition to Honolulu to secure a record of the appearances presented by the comet during the spring of 1910. Two cameras were employed, a 6-in. Brashear, f.l. 31·8 in., and a Bausch and Lomb Tessar lens of 57 mm. aperture, and 251 mm. f.l. The greatest length of tail photographed with the latter was 50° on May 14. The photographs obtained are described by Prof. E. E. Barnard, and no fewer than forty-seven are reproduced. The dates range from April 26–June 6. The Comet Committee also publish a very extensive index catalogue of photographs of the comet, giving date, time of exposure, optical constants, place, and an indication of the technical quality of the photograph.

PROBLEMS OF EFFICIENT METHODS OF DOMESTIC HEATING.

THE determination of the efficiencies of different methods of heating is a problem very difficult to solve on a purely scientific basis. It is, indeed, difficult to attach a precise meaning to the expression "efficiency" in connection with heating apparatus. The word as commonly understood in connection with devices for the utilisation of energy in any form means the ratio of the total amount of energy utilised to that consumed. In a heating apparatus it is difficult to say what fraction of the energy is to be regarded as "utilised." If we regard that heat only as utilised which is delivered into *the air* of a room, in one sense every apparatus which when suitably disposed delivers almost the whole of its heat into the air of a room may be regarded as having nearly the maximum possible efficiency—100 per cent. Such, for example, is the electric low-temperature stove (not taking into account the generating mechanism or boilers from which the heat is ultimately derived), or the oil stove, or the gas radiator, which deliver the products of combustion into the air of the room.

But heat is delivered into a room not only by convection currents of heated air, but also by the conversion of radiant energy into heat. The proportion of the radiant energy which may be converted into heat is essentially uncertain. It depends on the position of the radiant body relatively to the windows, walls, furniture, etc., and on other circumstances. If therefore the "efficiency" of the apparatus depends on such extraneous considerations, it is evidently out of place to use, in connection with this matter, such a word as "efficiency," which has a precisely defined significance. Alternatively we are debarred from regarding the air heat as the only "utilised" energy.

Functionally, a heating apparatus is one by which a certain amount of heat energy is passed through a room to the outer air. As a consequence of its passage, certain thermal and other conditions in the room are maintained. If the resistance interposed between the room and the outer air is relatively high, the same flow of heat will maintain a higher temperature than if the resistance is low. In the limit if the resistance were supposed infinitely great, the thermal conditions might be conceived to be maintained without any expenditure of heat whatever. It

will thus be evident that the word "efficiency" in connection with heating apparatus can have only a relative and not an absolute significance. At the best we can only compare the efficiency of different methods of heating relatively. But even in this the difficulties are at least equally great.

The only possible experimental means would be to maintain the same room in the same conditions in the same circumstances by each of the two methods, and to compare the amounts of energy expended in the two cases. But different methods of heating produce in the room widely different and varying thermal results which are very difficult either to compare, control, detect, or even to define. In a practical experiment on an existing room, it is impossible to exercise any control over the out-of-door conditions, such as the temperature, the humidity, and the air movement, otherwise than by enclosing the test building in another outer shell. This at once makes the experiment unreal and artificial, and could only be applied to a very few specially constructed rooms.

As regards the indoor conditions, we have simultaneously and independently to control and to measure the interchange, the humidity, and the movement, as well as certain obscure electrical conditions of the air, the air temperature, and what may be called the radiant temperature, which is an entirely independent function. All these factors are extremely difficult, either to control with accuracy or to measure. They all vary in different parts of the same room; the variation of any one of them would be sufficient to vitiate the scientific accuracy of any exact experiment. The loss of heat from a room depends to a notable degree on variations in all such factors, especially on the uncontrollable exterior conditions. Even so apparently simple a function as the internal temperature cannot be obtained even approximately by that of a simple thermometer. This latter reading depends on the shape, the nature of the surface, the mass, and material, of the thermometer itself. The radiant temperature especially varies from point to point over the whole area of a room heated by a hot body within it. A scientific comparison would therefore be of so unwieldy a nature that it would be almost useless as a practical guide.

A practical comparison can only be made with the reservation that such a comparison would not bear the brunt of scientific criticism. It would be impossible without some pedantry to leave out of count the practical object of all systems of heating, namely, to render the room heated comfortable to inhabit. A system which did not produce this result would be valueless, however theoretically "efficient" it might be. This introduces variations of individual idiosyncrasy. What is comfortable for one person is not so regarded by another. The physiologist and hygienist have also to be heard on the question. Conditions which are often regarded as comfortable may be notoriously unhealthy. Amid this diversity of considerations, it is difficult to establish a basis even of relative heating efficiency without laying down arbitrary conditions which may have little or no relation to the real problems involved. It is evident that the conditions to be produced must be specified in terms of physics and chemistry, so as to take the matter out of the subjective region.

The temperature condition of a room is very uncertain and difficult to ascertain, as the naked thermometer is a very untrustworthy criterion of the temperature of the air; it is equally so of the feeling of warmth in a room. Indeed its reading in a heated room indicates nothing but its own temperature. It is possible to obtain from different kinds of correct thermometers at the same point in a heated room indications which vary by as much as 10° or 12°. The true air temperature at the same point may be far different from either of the two. It is impossible to say which of these is the "correct temperature" without laying down arbitrary conditions. Thus it is absurd to take the identity of the reading of ordinary thermometers on two separate occasions as an indication that the room is in the same temperature condition on the two occasions. If it could be proved that the identity of the thermometer reading produced a similar sensation of warmth the practical significance of this objection might vanish, but this is notoriously untrue. The feeling of warmth is an exceedingly complex matter, and can only be measured by a different instrument altogether—a kind of electrical calorimeter, which has to be proved by physiological experiments of the most difficult character to give a true criterion of the feeling of warmth.

It would be futile even to make any comparison without taking account of the interchange of air. To estimate or control this is as difficult an experimental problem as any previously alluded to. It can only be done by introducing into and thoroughly mixing with the air of the room known quantities of an easily recognised gas, and afterwards making periodic analyses of the air at intervals. Mathematical calculations based on the results of these observations will then give the actual interchange. This complicated determination must be made, otherwise any possible kind of test would be altogether untrustworthy. The interchange of air generally accounts for half the total loss of heat.

As a rough practical basis of comparison between different systems of heating, we may take the relative amounts of energy necessary to be employed in a room in order to produce the same feeling of warmth as measured by a suitably calibrated instrument (not a thermometer), while maintaining approximately the same interchange of air.

The subjoined table is based on direct experiment in this sense, and refers to the cost of continuous uniform heating in certain natural or normal conditions, the full description of which would occupy much space. An alteration of the conditions would undoubtedly alter the percentages given. These values cannot, however, in any event be taken as the *practical* relative costs, because of the manner in which the respective methods of heating are commonly employed in practice. A hot-water heater or anthracite stove is generally burning all the day and frequently at night. A gas fire or electrical stove is usually turned off when the occupant leaves the room. When these latter agents are so employed, the function of the heater is not to maintain a continuous constant temperature throughout the room, but to provide rapidly and temporarily such radiant conditions, that the region near the heater is in a thermal condition (including the radiant condition), tolerable for persons to sit there. There is a wide difference between this and the maintenance of a continuous temperature throughout the room, and a set comparison between the "cost efficiency" is therefore misleading. Indeed, a comparison of cost cannot be reasonably made without a good deal of definition of requirements. It is probable, for instance, that in certain circumstances a good gas stove is a cheaper method of heating an occasionally used room than is an anthracite stove, although the cost efficiency of the latter is far below (*i.e.* more economical than) the former.

In order to enable the running cost to be calculated at different prices of the fuel (including in that term electrical power), it will be desirable to quote the rela-

tive equivalents of different agents, as compared with 1000 Board of Trade units of electrical energy.

TABLE OF EFFICIENCIES FOR CONTINUOUS HEATING.

The rates given are those current in London previous to the war and at present:—

Approximate equivalents.		Nominal relative Thermal efficiency.	Rates per unit.	Gross cost £	Relative cost
	Electric Radiator.				
1,000	Board of Trade Units of Electrical energy utilised in best radiant stove of 69% radiant efficiency disposed in the best manner.	Per cent. 100	1½d.	6·25	100
			3d.	12·5	200
			5d.	20·8	335
			6d.	25	400
	Open Fire.				
1·38 tons of best house coal, 14,000 B.T.U. per lb.	Burnt in bad grate unsuitably disposed.	8	26/-	1·8	29
			35/-	2·42	39
0·520 ton best house coal, 14,000 B.T.U. per lb.	Burnt in best open modern grate sunk in wall	21	26/-	0·675	10·8
			35/-	0·91	14·6
	Closed Anthracite Stove.				
0·235 ton best anthracite, 14,500 B.T.U. per lb.	Burnt in best modern slow combustion, closed anthracite stove ...	45	40/-	0·47	7·54
			50/-	0·59	9·42
	Gas Stove.				
18,300 cub. ft. gas, at 520 B.T.U. per cub. ft. ...	Burnt in medium old-fashioned gas fire (not worst type) ...	36	2/6	2·29	36·6
			3/-	2·75	44
10,700 cub. ft. gas, 520 B.T.U. per cub. ft. ..	Burnt in best modern ventilating gas stove	62	2/6	1·34	21·3
			3/-	1·60	25·6
	Water Radiators.				
0·198 ton of coke, 12,500 B.T.U. per lb.	Burnt in best provided modern water boiler with well-clothed circulation to radiators or pipes.	62	20/-	0·198	3·17
			30/-	0·297	4·75
0·306 ton of coke, 12,500 B.T.U. per lb.	In usual small house hot water installation as generally installed	40	20/-	0·306	4·9
			30/-	0·459	7·36
	Oil Stove.				
19·5 gallons petroleum 0·87 gravity, 20,240 B.T.U. per lb.	Completely burnt in any kind of stove discharging products into air of room ...	100	8d.	0·650	10·4
			10d.	0·810	13·0

ARTHUR H. BARKER.

THE PHYSIOLOGY OF INDUSTRIAL FATIGUE.[1]

THE gradual recognition of the prevalence among industrial workers of severe physical or mental fatigue has led during the last few years to a closer study of its harmful effects and to various suggestions as to its prevention. Although moderate fatigue is a healthy and natural event, there is little doubt that unduly prolonged hours of work, particularly if the work is carried on under unfavourable hygienic conditions, may lead to such a degree of fatigue that the efficiency and health of the worker are seriously impaired. The decline in efficiency manifests itself not only in a smaller output of work, but also in many occupations by an increased liability to accidents.

The prevention of extreme fatigue is, therefore, a matter of great importance, both to the employer and to the worker; but hitherto one of the most serious difficulties in the consideration of the problem has been the lack of any simple and certain test for the presence of fatigue. The question of finding a suitable index of fatigue has recently been taken up by Prof. Stanley Kent, and the preliminary results of his investigation are recorded in a report on industrial fatigue, which has been issued by the Home Office. Prof. Kent examined the influence of fatigue upon certain physiological phenomena, namely, the arterial blood-pressure, the reaction time in response to a simple stimulus, the acuity of hearing and of vision. The acuity of hearing was determined by noting the distance from the ear at which the ticking of a watch could be heard, and the acuity of vision was ascertained by noting the distance at which certain letters (test types) could be recognised.

The main experiments were carried out on three groups of workers—one group of six colliers, one group of six workmen in a chemical works, and one of six workers in the printing trade. The tests were applied twice daily, once before and once after the day's work, over a period of a week or more.

The experiments on the arterial blood-pressure and the reaction time yielded irregular and discordant results, but it was found that there was a striking diminution in the acuity of both vision and hearing at the end of the day's work, and that in many cases there was a progressive decline during the course of the week. The latter effect might be regarded as evidence of cumulative fatigue towards the end of the week. The decline in visual or auditory acuity was observed in all three groups of workers; in some members of each group the diminution amounted to 50 per cent. or more, whereas in others the change was so slight as probably to fall within the limits of normal daily variation apart from fatigue. The large variations in visual or auditory acuity in the same person on successive mornings, or on successive Monday mornings, when the subject was presumably not fatigued, are a prominent feature in Prof. Kent's results. These variations rather suggest that the subjective factor (as distinct from fatigue) is an important element in the test; and the fact that the test is purely "subjective," and that there is no means of checking the worker's statement as to the distance at which he hears a watch or sees a standard letter, is a distinct drawback to these tests.

Prof. Kent's observations also make it clear that, in some individuals, a day's work or a week's work leads to impairment of hearing but not of vision, or, on the contrary, to impairment of vision but not of hearing. This was noticed in each group of workers. It might be expected that, if the decline in visual or auditory acuity is a manifestation of general fatigue,

[1] Report on an Investigation of Industrial Fatigue by Physiological Methods. By Prof. A. F. S. Kent. (Home Office.)

both sight and hearing would be less acute in the fatigued person; and the fact that such is not always the case tells rather against the value of the tests as an index of fatigue. Taking into account, however, the comparatively small number of observations recorded up to the present by Prof. Kent, irregular results of this kind must be expected, and it is quite possible that a large series of observations would prove these anomalous results to be of minor importance. The simplicity of the tests and the ease with which they can be carried out is a strong argument for their adoption, provided that extended observation shows that they yield constant results.

THE CHILKA LAKE SURVEY.[1]

THE object of the memoirs referred to below is to inaugurate for the fauna of the brackish waters and waters of fluctuating salinity of the Indian coasts a register co-ordinate with that essayed by the *Investigator* for the Indian abyssal fauna. In the Chilka Lake, which is one of the best-defined and most strictly conditioned of these brackish tracts, and in the hands of such skilled explorers and many-sided zoologists as Dr. Annandale and Mr. Stanley Kemp, the undertaking makes a singularly happy inception.

The first instalment of the results of this Chilka survey contains a most interesting introduction to the topography and hydrography of the lake, and a detailed account of its Sponges, Cnidaria, Ctenophora, Oligochæta, Echiuroidea, Polyzoa, and Cirripedia: the introduction, the Echiuroidea, and the Ctenophora are the joint work of both authors; the short report on the Oligochæta is contributed by Col. J. Stephenson; for all the other groups Dr. Annandale is solely responsible. The second instalment is composed of four reports—on the Mysidacea, the Stomatopoda, the Mammals, Reptiles, and Batrachia, and the Aquatic Insects—the first being by Dr. W. M. Tattersall, and the last containing a contribution by Mr. F. F. Laidlaw.

The Chilka Lake is situated not far from the famous shrine of Jaganath at Puri, at the Mahanaddi Delta end of the tract of sand-waste, scrub, and screwpine-swamp that lies between the Ganjam hills and the Bay of Bengal. It is about forty miles long, with a maximum breadth of about sixteen miles, and a depth of a few feet; and in its origin it is a silted bay which—except for a mouth about 300 yards wide near the north-easterly limit—has been finally cut off from the sea by a narrow sand-spit formed (in the way usual along the east coast of India) by the strong northerly currents. By its narrow mouth it is in communication with the sea, while into the same north-easterly end run some of the waning effluents of the Mahanaddi Delta.

The survey under report embraced all the cardinal seasons of the year, and included 171 collecting stations. The observations show that in the wet season, when the Mahanaddi is in flood, the water of the lake is nowhere more than slightly saline, and over most of the area is quite fresh; while in the dry season it is nowhere anything but distinctly brackish, and in all the seaward area is as salt as the sea outside—facts of the greatest interest in their biological bearings.

The vegetation is considered mainly from the zoological point of view. Dense beds of Potamogeton give shelter to certain kinds of animals, and the leaves of a creeping Halophila afford anchorage to others; these are the characteristic water-weeds; for true seaweeds, of the higher kinds, are absent. At the water's edge there is little encouragement for sedentary organisms—no mangrove, and few screwpines, the most conspicuous shore-growth being a tall reed (Phragmites).

Beyond stating that the fauna as a whole is—as might be expected—mainly of marine origin, and specifying some distinctive features of the different habitats to which it conforms, the authors for the present make no generalisations outside the particular groups dealt with in their initial reports. Among interesting items it is noted that both fresh-water and marine sponges are found growing side by side, the former (Spongilla) being unable to resist high degrees of salinity, but the marine forms seeming perfectly comfortable in the wet season when the water is quite fresh; among the latter the world-wide *Cliona vastifica* and the Japanese *Suberites sericeus* are common, both producing gemmules in abundance. The Cœlenterates include eight or nine Hydrozoa, six Actinozoa, a Scyphomedusa, and a Ctenophore. The last, like several of the Hydrozoa, is a periodic visitor during favourable conditions; but the Scyphomedusa, though a common inhabitant of the Bay of Bengal, has established itself in the lake, and subsists, though in a state of repose, even when the water is quite fresh. Two species of Actinozoa (*Halianthus limnicola* and *Edwardsia tinctrix*) and one Hydrozoon (*Bimeria fluminalis*) seem also to be quite acclimatised, though the two first-named are inclined to be torpid, but with fecundity unaffected, in the fresh-water season. The barnacles of the lake belong to two widely distributed marine species, and also are inured to fresh water.

The common species of Squilla and all the four species of Mysidæ found in the lake appear to adapt themselves comfortably to all the seasonal changes of salinity. In the account of the aquatic insects, Mr. Laidlaw records as particularly noteworthy the existence in brackish water of the larvæ of an Agrionid dragonfly. The higher vertebrate fauna includes an otter, a dolphin (Orcella), the gharial and another crocodile, the hawksbill and edible turtles and a mud-tortoise, and three species of water-snakes.

The individual reports are instructive in fact and fertile in inference; all their regard for detail is infused with discernment; there is none of that assiduous piling up of wearying and bewildering minutiæ which so often makes eclectic work of this kind stale and unprofitable.

The memoirs are illustrated by numerous text-figures and twelve fine plates, which in the main are the work of those accomplished artists, Abhoya Charn Chowdhary and Shib Chunder Mondul.

[1] Memoirs of the Indian Museum, vol. v., No. 1, July. "Fauna of the Chilka Lake." By N. Annandale and S. Kemp. Pp. iii+156+plates. Price 15 rupees. Vol. v., No. 2, October. "Fauna of the Chilka Lake." Pp. 147–197+plates. Price 3.8 rupees. (Calcutta: Indian Museum 1915.

A VEGETATIVE CRUSTACEAN.[1]

EVERY text-book of zoology mentions, as one of the stock examples of degeneration, the curious cirripede, Sacculina, which lives as a parasite on crabs. Through the researches of Prof. Delage, more recently confirmed and extended by Mr. Geoffrey Smith, its life-history is now well known. After passing through free-swimming larval stages closely comparable with those of the normal barnacles, Sacculina attaches itself to its host and becomes endoparasitic, developing a system of branching roots which ultimately permeate all the organs of the crab. These roots radiate from a central mass of cells within which the sac-like body is differentiated, to emerge later on the surface beneath the crab's abdomen. While Sacculina is, as a rule, solitary, some related forms occur in considerable

[1] "On the Rhizocephalan genus Thompsonia, and its Relation to the Evolution of the Group." By F. A. Potts. Papers from the Department of Marine Biology of the Carnegie Institution of Washington, vol. viii., 1915. Pp. 32+2 plates.

numbers on a single host. The development of these has hitherto been something of a puzzle, since all the individuals found on one host are approximately in the same stage of development, and simultaneous infection by a swarm of larvæ seems improbable on account of the rare occurrence of the parasites. Mr. Geoffrey Smith, in 1906, made the suggestion that these gregarious parasites might be produced by some process of polyembryony or budding in the endoparasitic stage. He based the suggestion on the fact, observed by Delage and confirmed by himself, that the developing Sacculina may, as a rare exception, produce twin rudiments of the body within a single embryonic mass.

During the recent expedition sent by the Carnegie Institution of Washington to Torres Straits, Mr. F. A. Potts, of Cambridge, was able to investigate some of these "social" species of Rhizocephala and to obtain striking and conclusive evidence of the truth of this suggestion. The forms which he studied belong to the genus Thompsonia of Kossmann (with which he identifies Thylacoplethus of Coutière), and are parasites on various tropical crabs and shrimps. The saccular bodies occur in hundreds on the surface of the body and limbs of a single host, and are of much simpler structure than in the case of Sacculina. There is no mantle-cavity, nor are there genital ducts or associated glands, and the nervous system, reduced to a vestige in Sacculina, has entirely disappeared. Further, while Sacculina, like most cirripedes, is hermaphrodite, Thompsonia has no trace of male organs, and there is reason to believe that it reproduces solely by parthenogenesis. The sac-like bodies contain nothing but a mass of developing eggs or larvæ, which are set free in the so-called "cypris" stage, the earlier nauplius stage being suppressed. Mr. Potts was able to show that all the external sacs are in connection with a single continuous system of roots, and, further, that when the sacs are cast off by the moulting of the host (probably after their contained larvæ have been matured and set free), a fresh crop of sacs is budded off from the root-system.

It would scarcely seem possible to imagine a wider departure from our ordinary conception of an arthropod than that presented by Thompsonia, with its "mycelium-like root-system producing its singular asexual reproductive organs." Mr. Potts directs attention to the analogies it shows with certain Hydromedusæ. As if to complete the resemblance, he finds evidence that germ-cells are in some cases produced within the root-system, although he was unable to discover whether they migrate from thence into the developing buds as they migrate from the cœnosarc into the sexual buds of some Hydromedusæ. W. T. C.

CONDUCTION OF ELECTRICITY THROUGH METALS.[1]

THE power of transmitting large electric currents is one of the most characteristic properties of metals, and one to which they owe no insignificant fraction of their industrial importance. If we imagine for a moment the revolution that would be made in our daily life if metals did not possess this property, how much we rely upon it for light, locomotion, and communication, we shall realise how large a part it plays in our social life. It is not, however, on this aspect of metallic conduction that I wish to speak this evening, but rather on the mechanism by which the flow of current is produced, and the light which electric conduction throws on the structure of metals.

It is remarkable that though the quantity of electric current which flows any day or week through liquids or gases is quite insignificant in comparison with that which flows through metals, our views of the nature of conduction through gases or liquids are much more settled and definite than any we possess with respect to metals; it is remarkable, too, that progress in this subject is the outcome of the study of the flow of electricity through gases rather than through liquids, and that it is gases and not liquids which have given us the clue which promises to lead to the solution of the conduction of electricity through metals, which from many points of view is by far the most important case of conduction.

Many physicists have had the idea that the passage of electricity through metals might be analogous to that through liquids, where we have strong evidence that the current is carried by atoms or groups of atoms charged with electricity. Some of these atoms are charged with positive electricity, others with negative, but all help to carry the current, the positively charged ones by moving in the direction of the current, the negatively charged ones in the opposite direction; in the case of liquids the passage of the current is inextricably connected with the movement of atoms through the liquid. A familiar instance of this is the ordinary electrolytic bath for electroplating. Now, as I have said, some physicists had the idea that electric currents get through metals by the motion of charged atoms in much the same way as they get through liquid, and they naturally made experiments to see if they could detect any transport of metal which is so marked a feature when currents pass through liquids. Speaking generally, these experiments were of two types. In one type the current was sent through a wire made of an alloy of two metals. The proportion of the two metals in the wire before a current was passed through it was determined with great care. A powerful current was then sent through the wire for a long time, and the wire was again analysed, samples being cut from the end at which the current went in and also from the end at which it went out. If there had been any transport of atoms by the current, the composition of the end where the current entered would be different from that of the end where it left. The experiment showed that no difference could be detected, even when enough current had passed through the wire to carry all the metal in the wire from one electrode to the other if the metal had been in a salt dissolved in an electrolytic bath. The other type of experiment was to put plates of two metals, say gold and lead, together, taking care that there was good contact, and then send a strong current across the junction for a considerable time, and at the end of that time see if any lead had been carried into the gold or any gold into the lead. Not the slightest trace of any such transport could be detected. These experiments showed that the electricity was not carried through metals by charges on atoms or any combination of atoms, and as at that time no other carriers of electricity were known, the difficulties in the way of supposing that the current was carried by moving electric charges seemed insuperable. Relief, however, came from the study of the passage of electricity through gases, which showed that there were other carriers of electricity besides atoms.

These carriers, which are called corpuscles or electrons, are exceedingly small compared with the smallest atom known, that of hydrogen. They form a part of every kind of atom, and, however different the atoms from which the electrons come may be, the electrons themselves are invariable. There is only one kind of electron, and this has a mass of $\frac{1}{1700}$ that of a hydrogen atom, and carries a constant charge of *negative* electricity. The discovery of the corpuscle or electron put an entirely different com-

[1] Lecture delivered before the Institute of Metals by Sir J. J. Thomson, O.M., F.R.S.

plexion on the question of metallic conduction, for, if the carriers of the current are electrons and not atoms, if the conduction is electronic and not electrolytic, there need be no transport of the atoms of the metal by the current; if the electrons, which are of the same kind whatever the metal, can move, there is no need for the atoms to do so. Thus, if metals contain electrons which can move freely under an electric force, they would certainly conduct electricity, and thus physicists investigated the consequences of supposing that metallic conduction arose in this way. It is easy to get direct evidence of the existence of electrons in metals, for when the metals are raised to a very high temperature so as to be incandescent, as in the case of the filaments of electric lamps, large quantities of electrons are given off, and though the emission is greatly affected by the presence of gas in the metal, the behaviour of Coolidge tubes, in which a tungsten filament continues to give out electrons for months in the highest vacuum that can be obtained, shows that the presence of gas is not absolutely essential for the emission of electrons.

Let us, then, see what the electrical properties of a metal would be if it had free electrons disseminated through it, the metal acting as a cage for the electrons, which can move between the atoms of the metal. The assemblage of electrons is supposed to have the properties of a gas, and to be in temperature equilibrium with the metal—in other words, the electron temperature is the same as that of the metal. In gases the average kinetic energy of the molecules depends only upon the temperature, and not upon the nature of the gas; thus the average kinetic energy of the electrons will be the same as that of the molecules of air at the same temperature. As the mass of an electron is exceedingly small compared with that of a molecule of air, if the average kinetic energy of the two is to be the same, the average velocity of the electron must be very much greater than that of the air molecule. At 0° C. the velocity of the electron works out at 10^7 centimetres per second, or, roughly, sixty miles per second. If there is no electric force acting on the metal, then, though the motion of the electrons produces movement of electricity, there is no flow of electricity through the metal, for whatever is the number of electrons moving in any direction, there are just as many moving in the opposite. If, however, an external electric force is applied to the metal, the electrons under this force will, since they are negatively electrified, drift in the opposite direction to the force. This will cause a current, proportional to the number of electrons which pass in one second across a unit area drawn at right angles to the force, to flow through the metal. Thus, if n is the number of electrons per unit volume, e the charge on an electron, w the velocity of the drift,

$$n e w = \text{current through unit area.}$$

The velocity of drift w is proportional to the electric force X. Let it equal kX, then the current is kneX, and kne is the specific conductivity of the metal. Thus the presence of these electrons will make the metal a conductor of electricity. It will also give to the metal specific powers for the conduction of heat. For if different parts of the metal are at different temperatures, the electrons in those parts will also be at different temperatures, and thus the metal will be in the condition of being filled with a gas which is hotter at one place than it is at another. Confining our attention to the gas, heat will flow from the hot parts to the cold, and, as the kinetic theory of gases shows, the conductivity for heat of the gas will be proportional to nk. This is proportional to the specific conductivity of the metal for electricity. Thus that part of the conductivity for heat of the metal which arises from the presence of the electrons will be proportional to the electrical conductivity, and if the greater part of the heat conductivity is due to the presence of electrons, the thermal conductivity should bear a constant ratio to the electrical conductivity. Thus good conductors of heat should be good conductors of electricity; in fact, the two conductivities should bear a constant ratio to each other. Now, at any rate at ordinary temperatures, the constancy of this ratio is very remarkable. I will illustrate this in two ways: (1) by a table, and (2) by a diagram. The table, which is due to Jaeger and Diesselhorst, is as follows:—

Material	Thermal Conductivity / Electrical Conductivity At 18° C.	Temperature coefficient of this ratio. Per cent.
Copper, commercial ...	$6{\cdot}76\times10^{10}$ ...	—
Copper (1), pure	$6{\cdot}65\times10^{10}$ ...	0·39
Copper (2), pure	$6{\cdot}71\times10^{10}$ ...	0·39
Silver pure	$6{\cdot}86\times10^{10}$ ...	0·37
Gold (1)	$7{\cdot}27\times10^{10}$ ...	0·36
Gold (2), pure	$7{\cdot}09\times10^{10}$ ...	0·37
Nickel	$6{\cdot}99\times10^{10}$ ...	0·39
Zinc (1)	$7{\cdot}05\times10^{10}$ ...	0·38
Zinc (2), pure	$6{\cdot}72\times10^{10}$ ...	0·38
Cadmium, pure	$7{\cdot}06\times10^{10}$ ...	0·37
Lead, pure	$7{\cdot}15\times10^{10}$ ...	0·40
Tin, pure	$7{\cdot}35\times10^{10}$ ...	0·34
Aluminium	$6{\cdot}36\times10^{10}$ ...	0·43
Platinum (1)	$7{\cdot}76\times10^{10}$ ...	—
Platinum (2), pure ...	$7{\cdot}53\times10^{10}$ ...	0·46
Palladium	$7{\cdot}54\times10^{10}$ ...	0·46
Iron (1)	$8{\cdot}02\times10^{10}$ ...	0·43
Iron (2)	$8{\cdot}38\times10^{10}$ ...	0·44
Steel	$9{\cdot}03\times10^{10}$ ...	0·35
Bismuth	$9{\cdot}64\times10^{10}$ ...	0·15
Constantan (60 Cu, 40 Ni)	$11{\cdot}06\times10^{10}$ ...	0·23
Manganine (84 Cu, 14 Ni, 12 Mn)	$9{\cdot}14\times10^{10}$ ...	0·27

If we suppose that all the heat is carried by the electrons, the kinetic theory of gases (on certain assumptions as to the nature of the collisions between two electrons and an electron and an atom) leads to the equation:—

$$\frac{\text{Thermal conductivity}}{\text{Electrical conductivity}} = \frac{4}{3}\frac{a^2\theta}{e^2}.$$

Where e is the charge on an electron, θ the absolute temperature, and $a\theta$ the average kinetic energy of a molecule of a gas at this temperature, all these quantities are known. Substituting their values in the equation, we find that the ratio of the conductivities is $6{\cdot}3\times10^{10}$ and the temperature coefficient 0·366 per cent. The close agreement between these numbers and those determined by experiment is very remarkable.

Fig. 1 is a diagram which represents the electrical and thermal conductivities of alloys of bismuth and lead in varying proportions. It will be noticed that any sudden change in one conductivity is accompanied by a corresponding change in the other.

These results point to the conclusion that in metals not only the whole of the current but the greater part of the heat is carried by the electrons. This does not imply that the electrons are the only agents by which heat can be conducted, but merely that in metals most of the heat is carried in this way. In insulators such as glass, though the thermal conductivity is small, its ratio to electrical conductivity is very much greater than for metals.

The conception of free electrons in metals affords a ready explanation of many of their electrical properties. Let us consider for a moment what will happen if we put two different metals, A and B, into contact. Both A and B contain electrons, but one, A say, has more per unit volume than the other; thus the pressure of the electrons in A is greater than that of the electrons in B. Thus, when the two metals are put in contact, electrons will rush out of A into B. As these electrons carry negative electricity with them, B will be negatively electrified, and its electrification will increase until the repulsion it exerts on the electrons in A is sufficient to balance the excess of pressure, and to prevent any more electrons from passing from A to B. Those that do pass, however, will establish a difference of potential between A and B, and in this way we have a simple explanation of the difference of potential arising from the contact of metals.

Again, when an electric current passes through an unequally heated metal, electrons will drift from places of high to places of low potential, and carry heat with them; thus the passage of a current of electricity through an unequally heated conductor will alter the flow of heat. This is a well-known effect; it was

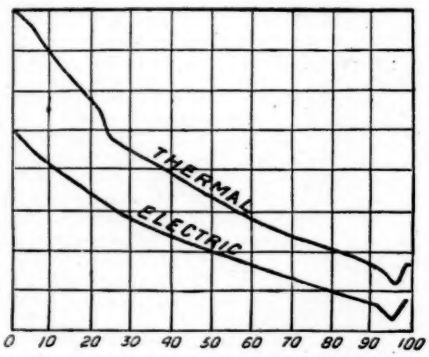

FIG. 1.—Conductivities of alloys of bismuth and lead.

discovered by Lord Kelvin, and is known as the Thomson effect. Closely connected with this is the effect produced when we suddenly heat one part of a conductor. This will raise the temperature of the electrons in that part and increase their pressure; they will overflow into other parts of the conductor, and the charges they carry will produce electromotive forces arising from unequal heatings. These, too, are a well-known feature of metallic conduction.

We thus see that the characteristic features of metallic conduction can be explained in a general way by the theory that free electrons are dispersed through the metal. We have not, however, considered as yet how many of these free electrons would be required to produce conductivity as great as that of metals. This is a very important point, for these free electrons will produce other effects besides electrical ones. While their presence endows the metal with electrical conductivity, the property we wish to explain, it also endows it with other properties which have to be explained away. We have to satisfy ourselves that the number of electrons required for metallic conduction is so small that the undesirable effects are negligible. Let us consider for a moment the nature of some of these effects. We have supposed the electrons to be in temperature equilibrium with the metal, so that when we heat the metal we also heat the electrons. Now, to raise the temperature of a number of electrons requires just as much energy as to raise that of the same number of molecules of air—the specific heat of electrons is the same as that of the same number of air molecules. And it might, and in certain cases we shall see that it does, happen that so many electrons were required to explain the metallic conduction that their specific heat would be considerably greater than the observed specific heat of the metal. This is even the case when we suppose that the increase in the temperature does not increase the number of the electrons. The production of free atoms from the metal is, however, a case of dissociation, a neutral atom of the metal dissociating into an electron and a positively charged atom. The dissociation might be expected to increase with temperature, so that when we raise the temperature we have to supply not merely the work required to raise the temperature of the electrons already present, but also the work required to detach fresh electrons, and this additional work will increase the apparent specific heat; thus the effective specific heat of a number of electrons may be considerably greater than that of the same number of molecules of air.

Another point, too, has to be taken into consideration: every electron present in the metal requires the presence of one positively electrified atom. If there are as many electrons as atoms, then, supposing each atom carries only one charge, every one of the metallic atoms must be charged with positive electricity; if there were six times as many electrons as atoms, each atom would have on the average to be charged with six units of electricity. So that any great excess of electrons over atoms is only possible if the atoms can receive positive charges which are many multiples of one unit. Now there are strong reasons for thinking that the number of positive charges on an atom, or, what is the same thing, the number of electrons which can be taken out of it, cannot, at any rate in the circumstances of the atoms in the metal, be any very large multiple of the atomic unit of electricity. It is true that we have reason to believe that there are in an atom a number of electrons equal to half the atomic weight, but the great majority of those are deeply seated and require the expenditure of large amounts of energy before they can be liberated. The number of electrons which can be detached from an atom of a metal in normal circumstances is probably quite small; and it would be a grave difficulty if, in order to explain metallic conductivity, we had to assume that the number of electrons was largely in excess of the number of atoms.

Let us now proceed to calculate the number of electrons required to explain metallic conduction. We have seen that the specific conductivity of a metal is equal to nke, where n is the number of electrons per unit volume, k the drift of the electrons under unit electric force (k is called the mobility of the electron), and e the charge on the electron. We know the specific conductivity, and e, and hence we can determine nk. I will, for the sake of definiteness, take the case of silver at 0° C. For this metal, $nk = 3{\cdot}9 \times 10^{18}$. The specific resistance gives us only the value of the product nk. To determine n we must, from other sources, form an estimate of k. I will consider two methods: the first, an indirect one based on values of k derived from experiments made on gases. The drift k, which can be compared with the terminal velocity acquired by a weight falling through a viscous liquid, depends upon the effects of the collisions which the electrons make with the atoms of the metal through which they are moving. Maxwell proved that where a particle drifts through a gas with a velocity u, it loses momentum at the rate βu; β is a coefficient directly proportional to the number of molecules per unit volume of the gas through which the

particle is drifting, and depends also upon the force which a molecule exerts on a particle when it comes near it. When the particle is under the action of an electric force X, the momentum communicated to it by the force per second is Xe; when it settles down to a steady state, the gain in momentum from the force must equal the loss from the impacts, so that $\beta u = Xe$ or $u = Xe/\beta$, and k must be equal to e/β. Let us try to estimate the value of k for metals, from the measurements which have been made of the drift of electrons in circumstances where it can be measured. In conduction through flames the negative electricity is carried by electrons, and at a temperature of 2000° C. the speed of the electrons under a force of a volt per centimetre is estimated at 10,000 centimetres per second. This would make the speed of an electron through air at normal pressure at 0° C. under the same electric force about 3300 centimetres per second. Now, in the air there are $2{\cdot}75\times10^{19}$ molecules per cubic centimetre, while in a cubic centimetre of silver there are about 6×10^{22} atoms of silver, about 2200 times the number of air molecules, hence we should expect the velocity of an electron in silver under a volt per centimetre would be about 3300/2200 or 1·5 centimetre per second. k is the velocity for unit force which is $1/10^8$ of a volt per centimetre, so that k should be about $1{\cdot}5\times10^{-8}$, and since $nk = 3{\cdot}9\times10^{16}$, n would be $2{\cdot}6\times10^{24}$. This is about forty times the number of silver atoms, so that the silver atoms would have on the average a charge of forty units. This number of electrons would exert a pressure of 100,000 atmospheres, and their specific heat in unit mass of silver would be many times the actual specific heat of silver.

We can also estimate the number of electrons required on this theory by considering the resistance of the metal under periodic instead of steady electric forces. If the electric force is represented by $X\cos pt$, then we can show that if u is the velocity of drift, m the mass of an electron,

$$m\frac{du}{dt} + \beta u = Xe\cos pt,$$

the solution of which is

$$u = \frac{Xe\cos(pt+\theta)}{\beta\sqrt{1+m^2p^2/\beta^2}}.$$

Thus the effective resistance under alternating currents is greater than that under steady currents in the proportion of $\{1+(m^2p^2/\beta^2)\}^{\frac{1}{2}}$ to 1. Now one very interesting case of alternating electric forces is that of a wave of light. Rubens has investigated the resistance of metals under the electric forces which occur in light of various wave-lengths. He finds that when the wave-length is greater than 2×10^{-3} centimetres the resistance is indistinguishable from that for steady currents, and when the wave-length is 4×10^{-4} centimetres the resistance is only 20 per cent. greater. It is the second of these results which we shall use to calculate β. p for a wave-length of 4×10^{-4} is $1{\cdot}5\times\pi10^{14}$, and if the resistance is increased by 20 per cent. $m^2p^2/\beta^2 = 2/5$, or $mp/\beta = 2/\pi$, approximately; thus $\beta = 7{\cdot}5\times10^{14}\times m$; and since $k = e/\beta$, and $e/m = 1{\cdot}7\times10^7$, $k = 2{\cdot}2\times10^{-8}$. As $nk = 3{\cdot}9\times10^{16}$, $n = 1{\cdot}8\times10^{24}$. This is not greatly different from the value we got by the preceding method, and leads again to the conclusion that to explain an electrical conductivity as large as that of silver requires a number of electrons so great that each atom of silver would have on an average to lose 20 or 30 electrons, and the specific heat of these would be far greater than the actual specific heat of silver.

A great deal of work has been done in recent years on the specific heats of metals, but, so far as I know, no effect has been found which can be traced to electrons, nor is there any trace of energy being absorbed in dissociating the atoms of the metal into electrons and positively charged atoms.

Variation of Electrical Resistance with Temperature.

The fact that to a considerable degree of approximation the electrical resistance of all pure metals is at all but the lowest temperatures proportional to the absolute temperature, is a result of such generality that we should expect it to be a direct consequence of any adequate theory of electrical resistance. On the theory that the conductivity is due to free electrons, this result, so far from being an obvious consequence of the theory, is very difficult to reconcile with it. The conductivity of the metal is, as we have seen, the product of two factors, n the number of free electrons, and k the mobility of an electron, and since the conductivity is approximately inversely proportional to the absolute temperature, nk must be very much greater at low temperatures than at high. Consider the factors separately, we certainly should not *a priori* expect n to be larger at low temperatures than at high ones, for we regard the free ions as due to the dissociation of the atoms of the metal, and thus to have much the same connection with temperature as the products of dissociation in such a case as the dissociation of molecules of iodine. In such cases, however, n is proportional to $e^{-\frac{w}{RT}}$, where T is the absolute temperature, R the gas constant, and w proportional to the work required to dissociate the system. Now this factor, instead of increasing as the temperature diminishes, decreases, and does so very rapidly indeed, when RT is small compared with w. If, then, the product nk is much greater at low temperatures than at higher ones, the increase must be due to the factor k—that is, the mobility of the system must increase very rapidly as the temperature diminishes. Now the theory of the motion of an electron through a number of centres of force, each of which acts on the electron with a force inversely proportional to the p^{th} power of the distance, leads to the result that k is proportional to $\theta^{\frac{2}{p-1}-\frac{1}{2}}/m$, where m is the number of attracting centres per unit volume and θ the temperature. The product nk varies approximately as $\theta^{-\frac{1}{2}}$, and since n diminishes as θ diminishes, k must increase more rapidly as θ diminishes than $\theta^{-\frac{1}{2}}$; for this to be the case p must be less than one, an extremely improbable result. If we suppose that the force exerted by a positively charged atom on the negative electron is so much greater than that exerted by a charged one that it is the collisions with the charged atoms that determine the mobility, $m=n$ and $p=2$, then nk varies $\theta^{\frac{1}{2}}$—*i.e.* the conductivity should increase with the temperature instead of diminishing.

The very remarkable results got within the last few years by Kamerlingh Onnes, in his experiments on the electrical resistance of metals at very low temperatures, seem to me to tell against the theory that the conduction is due to free electrons, while they receive a simple explanation on the theory which I am about to suggest. Kamerlingh Onnes finds that the resistance of some pure metals, such as mercury or lead at the temperature of liquid helium or thereabouts, becomes too small to be measured, and is certainly less than one-thousandth-millionth of its value at 0° C., whereas, if it diminished in proportion to the temperature it would only be diminished by one-seventieth. He has found, too, the very remarkable result that a current once started by moving a magnet in the neighbourhood of a lead ring at this temperature, lasted with little diminution more than two hours

without the application of any further electromotive force, and he estimates that it would take four days to fall to half its value; we have here a somewhat close approach to a perfect conductor. We saw that much smaller increases in conductivity at low temperatures were a difficulty in the way of the free electron theory, the enormous increases in the conductivity discovered by Kamerlingh Onnes make these difficulties much more formidable. These increases, however, admit of a very simple explanation on a theory which I suggested some time ago—in fact, the main features of the theory are the same as one I gave in my "Applications of Dynamics to Physics and Chemistry, 1888," except that as at that time the electron had not been discovered, I had to suppose that the electricity was carried by atoms; this involved the transport of the metal by the current, a difficulty which disappeared on the discovery of the electron.

Perhaps the clearest way of introducing the theory is to direct your attention to a theory with which many of you are doubtless familiar, that of the magnetisation of iron, which has many analogies with our theory. This theory of magnetisation supposes that a piece of iron is a collection of an immense number of little magnets, called molecular magnets; when the iron is not magnetised these molecular magnets are all higgledy-piggledy, so that they completely neutralise each other's effects, and the iron shows no sign of magnetisation. When, however, the iron is acted on by a magnetic force, the force acting on the magnet tends to make them swing round, so as to point in the direction of the force; the result is that more point in this direction than in any other. As some order is brought into their arrangement, they no longer neutralise each other, and the iron as a whole behaves like a magnet. The intensity of magnetisation will be measured by the excess of the number of those which point in the direction of the magnetic force over those which point in any other directions. Now, when the magnetic force acts on the iron, why do not all the magnets swing round and point in the direction of the force? It is because there are other causes at work tending to knock them out of line as fast as the magnetic force pulls them back. One of these causes is the knocking about they get in consequence of the movement of the molecules arising from their temperature. This is more violent at high temperatures than at low, and so more will be pulled into line by the same force at low temperatures than they would at high. There seems to be evidence that this is the cause that is most efficacious in preventing the complete set of the atoms; and Langevin has shown that, neglecting other effects and supposing the collisions are like those in a gas, the intensity of magnetisation can be represented by the expression

$$I = NM\left\{\frac{e^x+e^{-x}}{e^x-e^{-x}}-\frac{1}{x}\right\}$$

where

$$x=\frac{H^1M}{RT}.$$

N is the number of magnets per unit volume, M the moment of a little magnet, T the absolute temperature, R the gas constant, and H^1 the force acting on a little magnet. H^1 will consist of two parts, one the external magnetic force, the other due to the action of the magnets in its neighbourhood. This will be proportional to I; let it equal kI.

$$x=(H+kI)\frac{M}{RT}.$$

The graph representing the relation between x and I is thus a straight line, and to find the value of I corresponding to any value of H, we draw this line and find where it intersects the curve **U**, the equation of which is

$$I=NM\left(\frac{e^x+e^{-x}}{e^x-e^{-x}}-\frac{1}{x}\right)$$

and the graph of which is represented in Fig. 2.

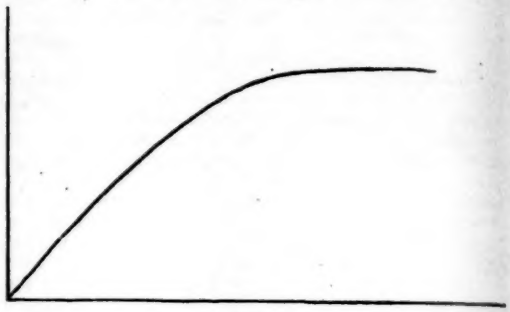

FIG. 2.

Let us now turn to the problem of the metal. We will suppose that each atom of the metal contains an electrical dipole—the electrical analogue of a molecular magnet. The molecular magnet consists of equal and opposite magnetic poles separated by a short distance. The electrical dipole consists of equal and opposite electrical charges at a short distance apart, the negative charge being an electron. These dipoles if acted on by an electrical force will set themselves along the lines of electric force, in the same fashion as the magnets along the lines of magnetic force; the result will be the same as if a certain fraction pointed in the direction of the electric force, while the remainder pointed indifferently in all directions. We thus shall have in the substance a number of chains of atoms arranged as in Fig. 3. So far there is nothing in the behaviour of these atoms which depends on the difference between a non-metal and a metal. The existence of these chains will produce what is called specific inductive capacity in the medium. But you will see that the doublets in the atoms will produce intense electric forces in their neighbourhood, and these forces will tend to drag the electrons out of one atom into the other. Now, on this theory, the difference between an insulator and a metal is that the electrons in an atom of an insulator are able to resist this pull and remain within the atom. In a metal, on the other hand, the electrons are much more easily detached, and yield to the pull, and electrons pass from one atom to another along the chain. Let us suppose that in consequence of this action p electrons pass along the

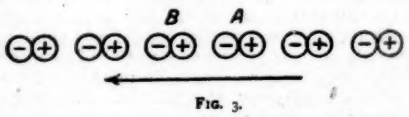

FIG. 3.

chain per second. The force which drags the electrons out is due to the pull exerted by the atoms in its neighbourhood, and so does not depend on the magnitude of the electric force. Since p electrons pass along each chain per second, the quantity of electricity which passes through unit area per second is Npe, where N is the number of chains through unit area, hence

$$i=Npe.$$

Now, if I is the number of doublets per unit volume which point in the direction of the electric force, and

d the distance between the centres of two doublets, the number of doublets in unit length of a chain $= 1/d$; hence $N/d = I$, or $i = Idpe$.

Now we have seen that

$$I = Nm\left(\frac{\epsilon^x + \epsilon^{-x}}{\epsilon^x + \epsilon^x} - \frac{1}{x}\right) = Nm\frac{x}{3}$$ along the straight part of the curve when n is smaller.

Also

$$x = \frac{m(X_0 + kI)}{R\theta}.$$

We determine for I, and therefore i, in terms of X_0, by the graphical method; but it will bring out the main points of the theory if I confine myself to intersections along the straight part of the curve, where

$$I = Nm\frac{x}{3} = \frac{Nm^2}{3}\frac{(X_0 + kI)}{RT}$$

So

$$I = \frac{\frac{Nm^2}{3}X_0 \times \frac{1}{RT}}{1 - \frac{Nm^2k}{3RT}}$$

Or if we take a temperature T_0, such that $\frac{Nm^2}{3RT_0}k = I$.

$$I = \frac{1}{k}\frac{X_0T_0}{T - T_0}$$

$$i = \frac{1}{k}\frac{X_0T_0dpe}{T - T_0}$$

Thus σ, the specific conductivity of the metal, $= \frac{1}{k}\frac{dpeT_0}{T - T_0}$.

Thus the conductivity becomes infinite, or the resistance vanishes when $T = T_0$. When we take the accurate solution instead of the approximate one, we find that the conductivity, though very great, is not infinite; the curve 1 bends round and meets the straight line, and when the intersection takes place in the curved portion the current no longer follows Ohm's law. We thus see that in the neighbourhood of a certain temperature the resistance diminishes with great rapidity, a point brought into great prominence by Kamerlingh Onnes.

If we compare the external force with the force kI, due to the atoms, we see from these equations that $kI/X_0 = T_0(T - T_0)$; so that near the critical temperature the force due to these atoms is enormously greater than the external force, so that the chains are held mainly by the forces between the atoms, and we can easily see by the graphical method of solution that when the temperature is below the critical temperature we can withdraw the electric force and still leave the greater part of the chains intact.

SUPER-CONDUCTIVITY.

Let us now consider what happens when the temperature is diminished; the slope of the line (1) continually decreases and the intersection of this line with the curve gets further and further away from the origin; when the intersection comes on a part of the curve at an appreciable distance from the tangent at the origin, Ohm's law will no longer hold. Suppose that the slope of the line (1) has fallen so that, as in Fig. 2, it is less than that of the tangent at the origin to the curve $I = NMF(x)$, and after the application of a force X_0 suppose the force is gradually removed, the value of I corresponding to the diminished force will be got by drawing parallels to PQ continually getting nearer to the origin, and its value when the force has been entirely removed by drawing a parallel through the origin itself. We see from the figure that in this case the line through the origin will intersect the curve again at S, showing that I retains the finite value SN after the electric force has disappeared. From the point of view of this paper, however, the part played by the electric force in metallic conduction is to polarise the metal, *i.e.*, to form chains: when once these are formed the electricity is transmitted along them by the forces exerted by the atoms on the electrons in their neighbours. Thus if the polarisation remains after the electric force is removed the current will remain too, just as it did in Kamerlingh Onnes' experiment with the lead ring. The argument is similar to that by which Weiss explained the existence of permanent magnetism below a critical temperature.

The remarkable results obtained by Kamerlingh Onnes only occur at the temperature of liquid helium; at the temperature of liquid hydrogen the metals show no sign of super-conductivity, the discovery of which is thus a result of being able to lower the lowest available temperature a few degrees; it is a very striking instance of the truth of Browning's line:

The little more and how much it is.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The General Board of Studies, in its annual report to the Senate, reviews the work done and progress made in the experimental departments of the University during the academic year, 1914–15. A large proportion of the scientific staff and some forty of the laboratory assistants are absent on military service; this, together with the enlistment of most of the students of military age, has led to a diminution of the usual output of original experimental investigation. A large amount of experimental work has been done gratuitously for a number of Government departments in connection with problems arising out of the war, and certain of the laboratories have been able to offer such facilities to professors of Belgian universities as have enabled them to continue the instruction of their pupils in this country.

The School of Forestry has been greatly assisted by Lord Cowdray, who has offered ample facilities for the practical study of forestry in his woodlands, which cover some seven square miles of country in Sussex. The research hospital is being used for the treatment of wounded officers under the control of the Army Council, and some 300 patients have been already received. The pathological museum has been enriched by a collection of specimens illustrating the effect of gunshot and other wounds on the bones and soft tissues, the material having been provided by the 1st Eastern General Hospital.

THE annual meetings of the Geographical Association will be held on January 6 and 7, at University College, London. On the morning of January 6, the presidential address will be delivered by Mr. H. J. Mackinder, and afterwards a discussion on "The First Steps in Geography Teaching" will be opened by Miss E. G. R. Taylor. In the afternoon Dr. Marion Newbigin will lecture on "The Geographical Study of Rivers," and the lecture will be followed by a discussion on "The Use of Home-made Apparatus," which will be opened by Mr. E. J. Orford. On the morning of January 7 a joint meeting of the Geographical and Historical Associations will be held, to discuss "The Relations of Geographical and Historical Teaching in Schools." Mr. H. J. Mackinder and Prof. Ramsay Muir will open the discussion.

PRACTICALLY the whole of our engineering colleges have now overcome the early difficulties and opposition which attended the starting of making munitions and otherwise rendering assistance in the present

emergency, and are now showing a production of gauges, gun parts, etc., which many engineers unacquainted with the capabilities of college workshops and staffs have found difficult to credit. Colleges not making munitions are training workers for the new munition factories, and many have undertaken researches of various kinds. Some information regarding the work in progress will be found in a paper by Dr. Walmsley and Mr. Larard, read at the Institution of Mechanical Engineers on December 17. It is to be hoped that the closer connection which exists at the present time between colleges and engineering works will not be broken when the war is over. Each side has much to learn from the other, and it promises well for the future that old prejudices on both sides are fast disappearing.

IT is announced in the issue of *Science* for December 10 that Mrs. Russell Sage has given Syracuse University a fund to build a college of agriculture as a memorial to her father. The building is to cost several hundred thousand dollars, the exact sum to be decided later. Our contemporary also states that a new building will be constructed for the University of Illinois Medical School in Chicago for the clinical courses. The initial cost is to be about 20,000*l.*, which will pay for one wing. This will be added to later as the demand for room increases. From the same source we learn that the trustees of Delaware College have made plans for the expenditure of a gift of 100,000*l.* to the college by an unnamed donor. A report submitted by the chairman of the Plans and Development Committee, which has been approved by the board, shows that 50,000*l.* will be used for a science hall to house the agricultural and chemical departments, 15,000*l.* to remodel the old dormitory building and turn it into a commons for the students, and 40,000*l.* will be set aside for maintenance.

AMONG the resolutions passed by the Headmasters Conference last week was one moved by Mr. A. L. Francis, headmaster of Blundell's School, Tiverton, "That in the opinion of this conference very grave loss to the country is caused by the employment of young students of exceptional mathematical and scientific ability as subalterns in Line battalions." Several important questions are raised by this resolution, but the chief point put forward by Mr. Francis was that the country should not permit itself to be deprived of its most ingenious and inventive brains in the grim struggles of the battlefield. "The place for the young man who has a special gift for science, mathematics, or mechanics is in the laboratory." Everyone will agree with this in principle, but the practical difficulty in deciding what students are sufficiently endowed with a "special gift" to be husbanded for national work in science and invention is another matter. The young students to whom Mr. Francis seemed to refer were those of Public School age, but it may be doubted whether at such an early stage it is possible to distinguish the few original minds which are destined to create new knowledge. Success in examinations certainly does not provide a true standard by which this genius for productiveness in science and invention may be measured. What we all deplore, and think should be avoided, is the sacrifice of men like Capt. J. W. Jenkinson and Lieut. Moseley, who had shown exceptional ability as original investigators. Apparently the Headmasters Conference does not object to the young students embraced by the resolution becoming subalterns in corps of engineers and artillery, where there are opportunities of applying a knowledge of science and mathematics, or even in the guards or the cavalry, where there may be no such need. Hundreds of able students of mathematics and science from university colleges and technical schools are at present serving as privates and non-commissioned officers in the Army, and the rank offered by the War Office to exceptional men in such subjects as chemistry and mining is not usually that of a subaltern but of a corporal.

THE annual report of the Royal Technical College, Glasgow, for the session 1914–15, has reached us. The "Roll of Members, Students, and Past Students on the King's Service" forms an appendix of a hundred pages. The roll comprises eight members of the governing body and of committees, 37 members of the staff, 1152 students of 1914 and 1915, and 622 students of previous sessions. These are serving in the following capacities:—Officers, 490; non-commissioned officers, 351; men, 966; nurse, 1; and on special service, 11. The appointment of 114 naval officers from the School of Navigation is specially noteworthy. The report records the deaths of ninety-one whose names appear on the roll. The reduction in the normal work of the college is indicated by the following comparative table of the number of students who enrolled:—

	Day students	Evening students	Total individuals
1914–15	445	2583	3028
1913–14	669	4342	5011

These enrolments necessarily include the large number of students who offered themselves during the session for active service, or who received appointments under firms manufacturing munitions. Many former members of the staff and students of the department of chemistry are now engaged in this work, and this department has made a contribution of about 150 men to the corps of chemists attached to the Royal Engineers. There are usually about 150 day students at work in the chemical laboratory during the session, but in the last week this number had dwindled to four, while of ten assistants on the staff only two were left. The plans for the increase of the new endowment fund initiated to extend the facilities available for higher studies and for research work have necessarily been postponed, but a grant of 520*l.* from the Bellahouston Trustees towards this object is acknowledged in the report.

SOCIETIES AND ACADEMIES.

LONDON.

Geological Society, December 1.—Dr. A. Smith Woodward, president, in the chair.—Dr. J. W. **Evans**: Petrological methods. The different methods of obtaining the directions-image ("interference figures") of a small mineral in a rock-slice, unaffected by the light from neighbouring minerals, were discussed. The author prefers the use of a diaphragm in the focus of the eyepiece, in conjunction with a Becke lens; he also described the inferences that might be drawn from the form, position, and movement on the rotation of the stage of the isogyres (dark bars or bushes) in the directions-images, both of chance sections and of those cut parallel to planes of optical symmetry or at right-angles to optical axes. He showed how the character or sign of the crystal and its approximate optic axial angle might be determined.

Linnean Society, December 16.—Prof. E. B. Poulton, president, in the chair.—E. S. **Goodrich**: The reproduction of Protodrilus. The author criticised the account given by Prof. U. Pierantoni, according to whom there are in most species of the genus male and hermaphrodite individuals. Dr. Orton having recently discovered *Protodrilus flavocapitatus* at Plymouth, the author has been able to study large numbers at the Marine Biological Laboratory. The appar-

ent males and females are about equal in size and number; but in ripe females spermatozoa can often be seen, and many of the ova are fertilised. Mr. Goodrich brought forward evidence that these spermatozoa are derived from the males, are not developed in the females, and that their presence is due to normal internal cross fertilisation between the sexes.—Miss Marietta **Pallis**: The structure and history of "Plav," the floating fen of the delta of the Danube. Plav is a Russian word: it signifies the floating thing or floating stuff, and is the name given by the fishermen of the delta of the Danube to a floating raft of vegetation built up almost entirely of living reed, *Phragmites communis*, Trin., *β. flavescens*, Gren. and Godr., and earth. The variation in length of the aerial portion of the reed-shoots is so striking (they vary from about 4 ft. to about 17 ft.), that it suggests the presence of different varieties of reed. Evidence is given that this variation is not specific or due to the factors of the environment, but is inherent in the reed. The different sizes of reed-shoots are held to be different branches of a definite and complicated reed-system, the first and final branches of which do not co-exist.—T. A. **Dymes**: The seed-mass and dispersal of *Helleborus foetidus*, Linn. The seeds of *H. foetidus*, L., are remarkable in being shed from the follicle in a single mass, bound more or less tightly together by a thick, white ventral strip of oleaginous tissue. Owing to the contrast of the shining elaiosome with the almost black seeds, the mass as a whole bears, at a short distance, a deceptive resemblance to the larva of a beetle. Observations were made, over two consecutive nights, on the work of the snails, which disintegrate the mass by devouring the elaiosome, thus reducing it eventually to single seeds. Experiments were also made with a view of establishing the possibility of molluscan dispersal of single seeds over a short distance. Observations in nature, and on captive *Helix aspersa*, point to the conclusion that the elaiosome offers an attraction as a molluscan dainty in the way of food. Experiments in the open do not support the idea of the larval resemblance being an adaptation to ornithochory, or that there is any regular dispersal by the birds of the neighbourhood. Observations and experiments with the ants, *Donisthorpea nigra* and *Myrmica laevinodis*, prove that they carry off whole masses, fragments, and single seeds, and take them into the nest. On the other hand, their behaviour does not favour the suggestion that the larval "mimicry" is operative, so far as they are concerned. The claim to myrmecochory is not a valid one. So far as the ants are concerned, neither the larval resemblance nor the massing brings to the species any advantage which it would not possess if the seeds were shed singly, as is usually, if not universally, the case with those that are adapted to these insects. The larval resemblance, which cannot be denied, suggests an adaptation to some still unrecognised agent or agents, and observations at the distributional headquarters of the species are much to be desired, in order to clear up the mystery of the mass.

MANCHESTER.

Literary and Philosophical Society, November 30.—Prof. S. J. Hickson, president, in the chair.—Prof. G. Elliot **Smith**: Further notes on pre-Columbian representations of the elephant in America. An amplification of the letter published in NATURE of November 25 (p. 340). Further examples of representations of the elephant were shown; and attention was directed to the fact that the Hindu god Indra, who was associated with the elephant, killed Vritra, who kept the rain in the clouds, just as the Central American elephant-headed god stood upon the head of the serpent, who prevented the rain from reaching the earth.—T. A. **Coward**: A change in the habits of the black-headed gull. Owing to the remarkable increase in its numbers since the Wild Birds' Protection Act of 1880, this gull has extended its range inland, and it is now an inland as well as a shore bird. This increase, in north Cheshire, has resulted in a noticeable change of habit, secondary to the change mentioned above, for within the last few years the bird has been roosting nightly on the waters of Rostherne Mere during autumn, winter, and early spring. Normally, the roosting and feeding hours of a bird which feeds upon the coast are regulated by the tides, but these Cheshire birds retire to roost like any other diurnal bird, about sundown. The area which these regular diurnal feeding and nocturnal sleeping black-heads frequent is contiguous to an area where others of the same species feed and sleep according to the constantly changing hours of the tide in the neighbouring Mersey estuary.

DUBLIN.

Royal Irish Academy, December 13.—Sir John Ross of Bladensburg, vice-president, in the chair.—H. **Ryan** and J. **Algar**: Studies in the diflavone group. III.—Derivatives of dicoumaranone and of diflavanone. Dianisylidenediacetoresorcinol, which was prepared by condensing anisaldehyde with diacetoresorcinol, was converted into its diacetatetetrabromide. Alcoholic potash converted the latter compound into dianisylidenedicoumaranone, instead of forming, as might be expected, di-*p*-methoxydiflavone. In the presence of alcoholic hydrochloric acid dianisylidenediacetoresorcinol interacted with anisaldehyde to form anisylidene-2-*p*-methoxycinnamoyl-3-hydroxy-4′-methoxyflavanone, and also dianisylidene-4:4′-dimethoxydiflavanone.—H. **Ryan** and M. J. **Walsh**: Studies in the diflavone group. IV.—Diveratrylidenedicoumaranone. By condensing veratric aldehyde with diacetoresorcinol a crystalline solid (diveratrylidenediacetoresorcinol), the constitution of which resembles somewhat that usually attributed to curcumindimethyl ether, was obtained. Unlike curcumin, however, the substance can scarcely be regarded as a mordant dye. It formed a crystalline diacetate, which readily added on bromine, and the product, on warming with potash, gave diveratrylidenedicoumaranone.—H. **Ryan** and Miss G. **Plunkett**: Unsaturated *β*-diketones. III. By the condensation of veratrylideneacetone with dimethyl oxalate a diketone, 3:4-dimethoxycinnamoylpyruvic methyl ester, was obtained. It formed an *iso*oxazole and a benzeneazo-derivative. Gentle hydrolysis converted it into the corresponding acid. The substances are mordant dyes, and, with mordanted wool, give colours very similar to those got with curcumin, the dimethyl ether of which they probably resemble in constitution.—H. **Ryan** and Miss A. **Devine**: The condensation of aldehydes with ketones. III.—Aldehydes with methyl-ethyl-ketone. α-Benzylidenemethyl-ethyl-ketone reacts with benzaldehyde in the presence of aqueous alkali to form a crystalline compound, $C_{18}H_{18}O_2$, which melts at 83–86°. It, as well as α-benzylidenemethyl-ethyl-ketone, interacts with benzaldehyde in the presence of alcoholic hydrochloric acid to form a colourless crystalline solid, $C_{25}H_{20}O$, which melts at 156° C. The latter compound may also be got by the action of excess of benzaldehyde on methyl ethyl ketone in the presence of alcoholic hydrochloric acid. α-Benzylidenemethyl-ethyl-ketone reacts with anisaldehyde and with piperonal to give the crystalline compounds $C_{27}H_{24}O_3$ and $C_{27}H_{20}O_5$ respectively, and also one molecule of methyl-ethyl-ketone condenses with piperonal to form a crystalline solid which has the formula $C_{21}H_{20}O_7$. The compound $C_{18}H_{14}O_2$ forms an oxime, but the compound $C_{25}H_{20}O$ forms neither an oxime nor a phenylhydrazone. With excess of bromine it gives a dibromide, $C_{25}H_{20}OBr_2$.

PARIS.

Academy of Sciences, December 13.—M. Ed. Perrier in the chair.—G. **Bigourdan**: The forgotten astronomer, Jean de Lignières, and the renaissance of astronomy in Europe. Riccioli ("Astronomia Reformata," 1665), giving the latitudes and longitudes of various stars, reproduced a small catalogue, the author of which was unknown to him, and since called by the name of *Astronomus incognitus*. Reasons are now given showing that this unknown astronomer was Jean de Lignières, a master of the University of Paris. The positions given in this catalogue are for the year 1364. —G. **Humbert**: The approximation of real irrationals. —H. **Douvillé**: The Orbitoïds of the Danian and of the Tertiary.—J. **Guillaume**: Observations of the sun made at the Observatory of Lyons during the second quarter of 1915. The observations made on seventy-two days are tabulated, showing the number of spots, their distribution in latitude, and the distribution of the faculæ in latitude.—M. **Mesnager**: The elastic equilibrium of an indefinite plate of uniform thickness, compressed by two equal and opposite forces uniformly distributed along two parallel right lines situated in a plane normal to the bases.—Pierre **Breteau**: The preparation of phosphorescent calcium sulphide. Modifications of Verneuil's method are suggested. The sulphide is first prepared from a mixture of calcium carbonate and sulphur by ignition at a red heat, and this is then impregnated with 1/10,000 of its weight of bismuth. This is again raised to a red heat and allowed to cool slowly.—Mlle. Yvonne **Dehorne**: An Actinostromid of the Cenomanian.—J. **Repelin**: The discovery of deposits of large Pythonomorphs in the Upper Cretacean in the neighbourhood of Jerusalem.—Ph. **Flajolet**: Perturbation of the magnetic meridian at Lyons (Saint-Genis-Laval) during the second quarter of 1915.—A. F. **Legendre**: General considerations on the structural forms of south-western China and the Tibetian borders.—C. **Sauvageau**: The commencements of the development of *Saccorhiza bulbosa*. —Arthur **Compton**: The influence of some meteorological factors on the appearance of cases of cerebro-spinal meningitis. The degree of humidity of the atmosphere would appear to be a meteorological factor of great importance in determining the appearance of this disease when the organism is already present in the country.—M. **Weinberg** and P. F. **Séguin**: Researches on gas gangrene. This communication gives the results of the study of a hundred cases of this infection, together with suggestions for a serum treatment.—E. **Vasticar**: The terminations of the acoustic nerve.

BOOKS RECEIVED.

Illustrations of the New Zealand Flora. Edited by T. F. Cheeseman, with the assistance of W. B. Hemsley; the plates drawn by Miss M. Smith. Vol. i. Pp. 8+121 plates and descriptions. Vol. ii. Plates 122–250 and descriptions+pp. xxxiv. (Wellington, N.Z.: J. Mackay.)

Transactions of the English Ceramic Society. Vol. xiv. Session 1914–15. (Stoke-on-Trent: The Society.)

Department of Marine and Fisheries. Report of the Meteorological Service of Canada, Central Office, Toronto, for the Year ended December 31, 1912. Vol. i., Introduction and Parts i.–iii. Pp. xvi+367. Vol. ii., parts iv.–vi. Pp. 368–568. (Ottawa: J. de L. Taché.)

An Introduction to the Principles of Physical Chemistry from the Standpoint of Modern Atomistics and Thermodynamics. By Prof. E. W. Washburn. Pp. xxv+445. (New York: McGraw-Hill Book Company, Inc.; London: Hill Publishing Co., Ltd.) 15*s.* net.

Hancock's Applied Mechanics for Beginners. Revised and rewritten. By Prof. H. C. Riggs. Pp. xiii+441. (New York: The Macmillan Co.; London: Macmillan and Co., Ltd.) 10*s.* 6*d.* net.

The Wheat Industry. By N. A. Bengtson and D. Griffith. Pp. xiii+341. New York: The Macmillan Company; London: Macmillan and Co., Ltd.) 3*s.* net.

Catalysis and its Industrial Applications. By E. Jobling. Pp. viii+120. (London: J. and A. Churchill.) 2*s.* 6*d.* net.

DIARY OF SOCIETIES.

MONDAY, JANUARY 3.

ARISTOTELIAN SOCIETY, at 8.—Time, Space, and Relativity: Prof. A. N. Whitehead

SOCIETY OF CHEMICAL INDUSTRY, at 8.

TUESDAY, JANUARY 4.

RÖNTGEN SOCIETY, at 8.15.—Some Observations upon the Occurrence of Uranium: J. H. Gardiner.

WEDNESDAY, JANUARY 5.

GEOLOGICAL SOCIETY, at 5.30.—The Islay Anticline (Inner Hebrides): E. B. Bailey.

THURSDAY, JANUARY 6.

OPTICAL SOCIETY, at 8.—The Use of a Graticule in Binoculars and Telescopes: S. D. Chalmers.

FRIDAY, JANUARY 7.

GEOLOGISTS' ASSOCIATION, at 7.30.—The Discovery and Excavation of a Large Specimen of *Elephas antiquus* near Chatham: Dr. C. W. Andrews.

CONTENTS.

	PAGE
Scientific Research and Chemical Industry	475
The Molecular Volumes of Liquids. By **Sir T. E. Thorpe, C.B., F.R.S.**	476
The Partitions of Numbers	478
The Tintometer	478
Our Bookshelf	479
Letters to the Editor:—	
An Application of the Rules of Zoological Nomenclature.—**Dr. P. Chalmers Mitchell, F.R.S.**	480
The Scientific Organisation of Industries. By **Sir William Ramsay, K.C.B., F.R.S.**	480
Mothercraft and Infant Welfare. By **Prof. R. T. Hewlett**	482
Medical Research	483
Food Economy	483
Sir John Rhys. By **E. B. P.**	484
Notes	484
Our Astronomical Column:—	
Sun-spots and Pressure	490
Harmonic Analysis of the Motions of the Helium Stars	490
The Astronomical and Astrophysical Society of America	490
Problems of Efficient Methods of Domestic Heating. By **Arthur H. Barker**	490
The Physiology of Industrial Fatigue	492
The Chilka Lake Survey	493
A Vegetative Crustacean. By **W. T. C.**	493
Conduction of Electricity through Metals. (*With Diagrams.*) By **Sir J. J. Thomson, O.M., F.R.S.**	494
University and Educational Intelligence	499
Societies and Academies	500
Books Received	502
Diary of Societies	502

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